R.A. Rood
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British Telecommunications Engineering

VOL 1 PART 3 OCTOBER 1982

The Journal of
The Institution of British Telecommunications Engineers

BRITISH TELECOMMUNICATIONS ENGINEERING

VOL 1 PART 3 OCTOBER 1982

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Published in April, July, October and January by *British Telecommunications Engineering Journal*,
2–12 Gresham Street, London EC2V 7AG.
(Formerly *The Post Office Electrical Engineers' Journal* Vols. 1–74: April 1908–January 1982)
Price: 80p (£1.30 including postage and packaging). Orders by post only.

Annual subscription (including postage and packaging): home and overseas £5·20.
(Canada and the USA $12·00).

Price to British Telecom and British Post Office staff: 48p.

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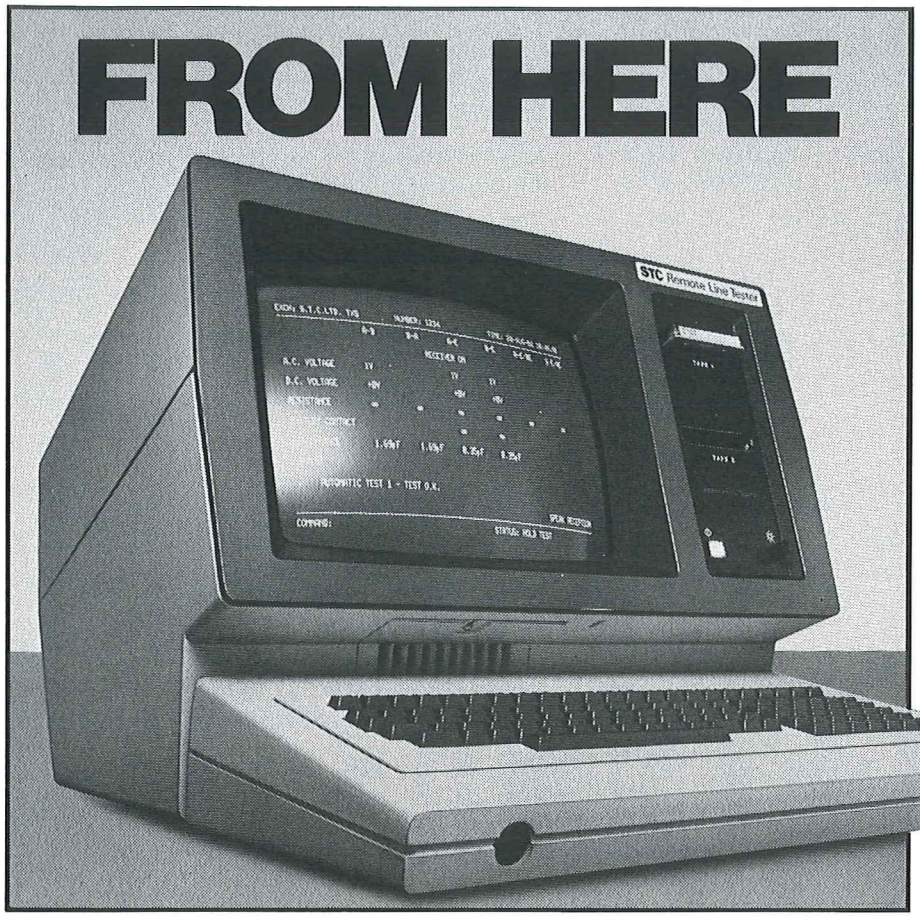

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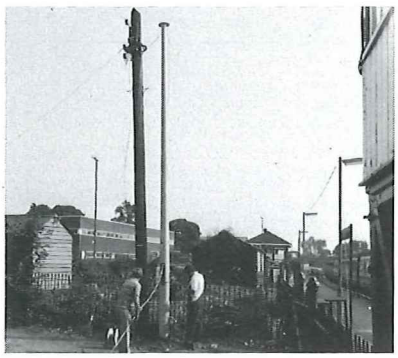

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EDITORIAL

Major developments in the field of opto-electronics have been recently announced by British Telecom (BT), and the inauguration by BT in July this year of the world's longest optical-fibre communication link has highlighted the UK's lead in optical communications. These developments, the fruition of many years of research by both BT and industry, are coincident with Government legislation for the liberalisation of telecommunication services in the UK. To meet this changing environment and to satisfy the needs of business and society generally, BT is planning to introduce an integrated digital network (IDN) and ultimately an integrated services digital network (ISDN). For these networks, digital transmission systems, in particular, optical-fibre systems, are vitally important. However, to achieve maximum benefit for both the customer and the administration, the provision of digital exchanges interconnected by digital transmission systems needs careful planning. In this issue of the *Journal*, the general trends in telecommunications are reviewed and the overall strategy behind BT's plans for modernising the network are discussed. A third article discusses the implications of these plans for the transmission network. Although the introduction of these new services is initially aimed at the business community, the residential customer also will benefit as a result of the general improvement in transmission standards. Of specific importance to the residential customer is the recent development of the all-electronic telephones. These press-button telephones are now being introduced as the standard basic telephone to replace the 700-series instruments, which have been dominant for more than 25 years. An article on p. 148 of this *Journal* introduces a series of articles which will describe these new ranges of telephone.

Trends in Telecommunications

SIR GEORGE JEFFERSON, C.B.E., B.SC., F.ENG., F.C.G.L.I., F.R.Ae.S., F.B.I.M., F.R.S.A., M.I.MECH.E.†

UDC 621.39

In this article the author discusses the 2 main evolutionary trends in communication today. Firstly, the mechanical switching systems and analogue transmission techniques of the public telephone network that are being swept aside by digital switching and transmission, with both techniques making heavy use of silicon-chip technology. Secondly, the new services that are becoming available, mostly for business, some being led by new opportunities opened up by digital transmission and switching, with particular reference to the role of satellites, and others being driven by the entry of silicon technology into commercial practice. This article first appeared in Electronics and Power, and is reproduced with the permission of the Institution of Electrical Engineers.*

INTRODUCTION

The British telecommunication network is the fourth largest in the world, is fully automatic and provides a relatively high quality of service. But in common with all other networks in the world, it suffers from constraints that inhibit its future development. It is dominated by electromechanical switching equipment, which is expensive, sensitive to cost inflation, slow in operation, liable to introduce circuit noise, fault prone and limited in its capability to provide new services.

Technical and economic studies show that the most economical way ahead is to modernise the telephone network by the provision of digital exchanges interconnected by digital transmission systems with processor-controlled inter-exchange signalling.

Indications are that the total capital cost of the network can be reduced by as much as 50% by conversion to digital techniques. Other advantages include faster call set-up time, increased reliability and more stable transmission with reduced circuit noise. Conversion also brings nearer the day when a wide range of other digital services can be passed efficiently through the basic telephone network.

The requirements for digital switching will be met by System X, a family of advanced software-controlled systems. They are highly modular in design to provide an evolutionary compatibility that will enable new devices and techniques to be introduced as they become available without changing the architecture of the system as a whole. A range of digital cable and radio multi-channel transmission systems has been developed to link the digital exchanges; these operate at speeds ranging from 2 Mbit/s (30 telephony channels) to 140 Mbit/s (1920 telephony channels).

Optical-fibre digital systems will be the main vehicle for modernising the transmission network, accounting for about half the trunk capacity by 1990. After a number of successful trials, production systems are being introduced into the network in ever increasing quantities.

DIGITAL TRANSMISSION

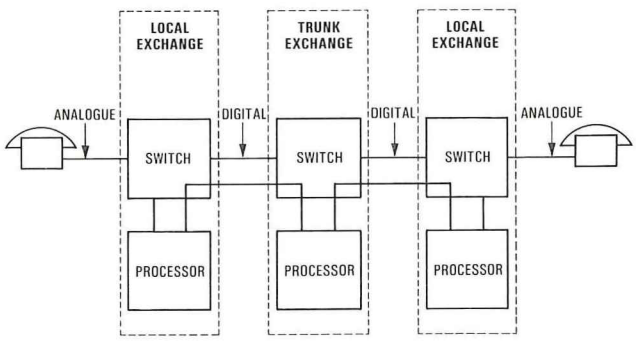
International digital transmission will develop rapidly from 1984, with time-division multiple access (TDMA) operation on both European and inter-continental satellites and optical-fibre submarine cables starting on a small scale in 1984 and being used for most new systems from 1986. An inter-continental digital cable across the Atlantic is likely to be in operation in 1988.

British Telecom's (BT's) target is substantially to complete the modernisation of the network by the early-1990s and to give priority to providing digital facilities for business customers. It is planned to create an integrated digital network (IDN) servicing the 30 major cities by 1985/86.

Development work is already in progress to extend the integrated digital network to customers' premises—by digital transmission with enhanced customer-to-network signalling—so that an all-purpose integrated-services digital network (ISDN) can be created. This will overcome the constraints on service potential imposed by conventional line and signalling techniques. A pilot ISDN will be established in London in 1983, extended to Birmingham and Manchester in 1984, and then will progressively penetrate the network as it is modernised.

Initial implementation of ISDN will use digital access over the existing 2-wire local distribution network at 80 kbit/s, via network terminating equipment. This access carries a high-speed channel of 64 kbit/s, a low-speed channel of 8 kbit/s and a so-called *D channel* of 8 kbit/s for customer/network signalling.

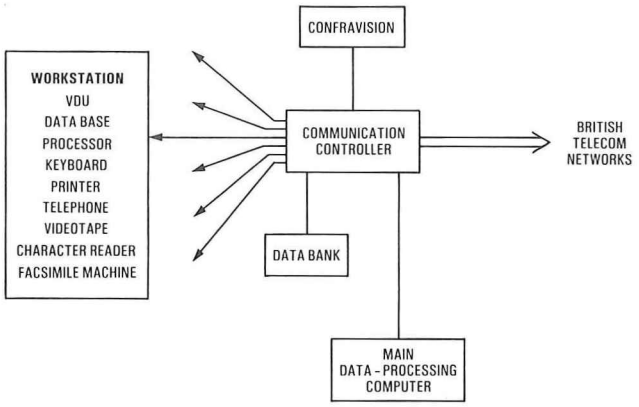
The high-speed channel will be used for digital telephony, fast circuit-switched data, facsimile etc. Lower-speed services, more consistent with man–machine interaction times, can be carried on the low-speed channel. Access to the System X local exchange will be provided via a remote multiplexer for those customers situated on the fringes of the exchange service area.



Block diagram of the integrated digital network

† Chairman, British Telecom.

* JEFFERSON, SIR GEORGE. Trends in telecommunications. *Electronics and Power*, June 82, **28** (6), pp. 438–442.



Communication in the office of the future

It is clear that as a result of all these network developments the future communication scene will be one of a wide and expanding range of voice, text, data and visual services. The office of the future will make widespread use of word processors, the storage, manipulation and retrieval of information, and new methods of communication. Microprocessors will also enter the home, providing a variety of services. Growth will also be seen in cable television and other services based on local wideband networks, including new forms of interactive entertainment and education, news distribution and information retrieval, electronic mail, home access to banking services, mail order and home-security facilities.

The trend towards the cashless society will continue through increased use of cheques, credit cards and electronic fund transfers (EFTs). Bulk EFTs already operate between banks and for transfering salaries from payroll computers to employees' bank accounts, and it is now entering the retail field through cash dispensing machines and point-of-sale terminals.

Teleconferencing will be promoted as an alternative to business travel. BT's Confravision service, which interconnects public studios in London, Birmingham, Bristol, Glasgow, Leeds and Manchester, has demonstrated that there is real interest in videoconferencing but that it must be made cheaper and more convenient to the user. However, by the mid-1980s, tariffs for both national and international videoconferences between private premises may be cut to only 5–10 times the standard-rate telephone call.

TELETEX

A pilot service of another new development, Teletex, started this summer. This is a high-speed, desk-to-desk message service which allows users to type and edit letters and dispatch them immediately to the recipient over the telephone or packet-switched data networks. Typically, a full page of text can be transmitted in a few seconds. Setting up, sending and receiving calls will be fully automatic, with facilities for storing incoming and outgoing messages.

Although the IDN will have substantially penetrated the UK network by the mid-1980s, there is considerable pressure from customers for higher-speed data services than can be provided on the analogue network. BT is responding to the need in a number of ways.

A variety of Datel services using the telephone network have been introduced to provide a switched data service, up to the current limit of 1200 bit/s full duplex (that is, with simultaneous operation in both directions) or 9600 bit/s half duplex (both ways, but only one way at a time). Within the next 12 months 2400 bit/s full duplex will be feasible, but this is probably the maximum on the switched network. Full duplex operation at 9600 bit/s is provided on leased lines. Where higher bit rates are required, a group of telephone channels can be leased; in this way data rates up to about 120 kbit/s can be carried.

SWITCHSTREAM

To meet the need for better switched data services than can be provided over the public switched telephone network (PSTN), a separate packet-switched service is marketed by BT under the title *SwitchStream 1*. This carries data at rates to 48 kbit/s and offers customers significant service improvements, including error checking and protection. Connection to similar data networks in other countries is available via the international packet switched service.

Responding to demand for improved leased-line data services, BT is currently establishing a national digital private-circuit service. This will exploit the increasing availability of digital transmission plant to provide a range of *KiloStream* services from 2·4 kbit/s to 48 kbit/s and broadband *MegaStream* digital circuits from 2 Mbit/s upwards.

Finally, the long established Telex network, which has more than 90 000 users, is being modernised by the introduction of processor-controlled Telex exchanges with advanced facilities such as store and forward, multiple delivery, broadcast and means for allowing machines operating at different speeds and with different codes to interconnect.

SATELLITE SERVICES

As far as prospective satellite services are concerned, it is clear that satellites must compete with the terrestrial transmission media—typically coaxial cable, microwave radio-relay and now optical-fibre cable—for traffic. For the basic business of a telecommunications undertaking, typically connecting telephone customers at points A and B, the terrestrial media are usually much cheaper over short distances, in densely populated, well-developed parts of the world. It is also true that the transmission delay of a geostationary satellite link—up to 0·3 s each way—does not help telephone conversation.

On the other hand, satellite communication has several positive advantages:

(*a*) Terrestrial-circuit costs increase roughly in proportion to distance, whereas satellite circuit costs are relatively independent of distance; the economic crossover point is likely to be at thousands of kilometres on major routes carrying thousands of telephone circuits; for lighter routes, the crossover point will be at a few hundreds of kilometres.

(*b*) Satellites can provide high-grade communication facilities to ships and aircraft, including dependable telephones and high-speed digital services; this is technically impossible at great distances by other means.

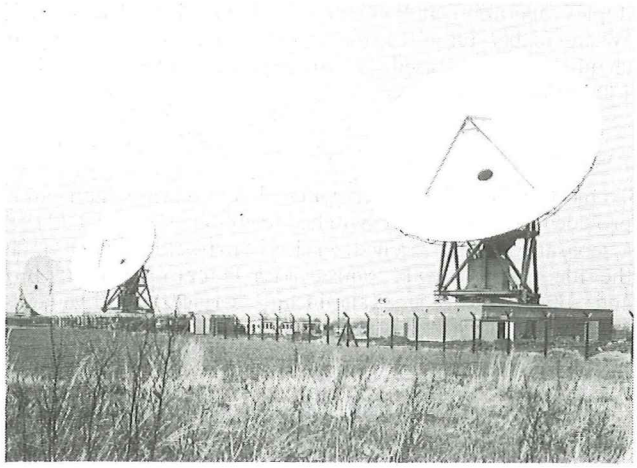
(*c*) With transportable earth stations, wideband links can be set up at short notice by satellite; temporary terrestrial wideband facilities are often cumbersome to set up and virtually impracticable except for short hauls.

(*d*) Point-to-multipoint operation is relatively economical.

(*e*) Terrestrial communication may be impeded by geographical features such as wide stretches of water, mountains, forests and unfriendly neighbours; satellite communication is not impeded by these barriers.

Just as geographical barriers may block any kind of terrestrial communication, limitations of the terrestrial network may form a technical barrier to new kinds of service. Thus, satellites can provide high-speed digital, wideband-analogue and flexible-capacity services on a point-to-point, point-to-multipoint, part-time and variable-destination basis.

The conventional terrestrial network was designed to do none of these things; it is sometimes noisy, and switched connections suffer occasional short interruptions. It is being modernised rapidly, and in time will no doubt escape these



British Telecom's earth station at Madley

limitations; but meanwhile satellites have the edge. So what will be the place of satellite communication in BT's network?

A variety of applications exploit one or more of the special advantages of the satellite medium. First and foremost, use of the INTELSAT system for inter-continental services will continue to grow. BT's 6 earth terminals at Goonhilly and Madley carry about 6000 telephone circuits, or the equivalent, today, using INTELSAT satellites over the Atlantic and Indian Oceans to obtain direct access to 81 other countries. Most of these circuits are used for the PSTN. Two more earth terminals are under construction, to help carry traffic growing at 30% per annum. Most of these circuits are analogue now, but digital connections are already possible and a general conversion to digital operation will begin in 1984.

A ninth earth terminal is being built at Madley to give access from 1984 to European telephone networks via the European Communications Satellite (ECS), managed by EUTELSAT. The ECS system will be digital from the start, and BT's first digital international switching centre will start service in 1984 at Keybridge House in London.

These developments will complement the digital conversion of the terrestrial transmission and switching network and bring nearer the day of the international ISDN. Most future submarine cable systems will use digital transmission, but economical conversion of existing cables to digital operation is not generally feasible. Submarine cables do not normally carry television signals.

Television Transmission

Each of the INTELSAT satellites sets aside one transponder for short-term international television connections. On special occasions this capacity may have to be multiplied by 2 or 3.

The UK is a big user of these facilities; on an average day Goonhilly and Madley handle 15 inter-continental video connections for various broadcasting organisations and television news agencies, and this traffic is growing. At present the Eurovision network is terrestrial, with European short-term television connections being provided by radio-relay link, including a cross-channel link with France. However, the European Broadcasting Union is leasing 2 transponders in ECS, starting in 1984, to provide an efficient and flexible video transmission medium between the various European earth stations that will be involved, including Madley.

Point-to-multipoint television-programme distribution services are the mainstay of US domestic satellite systems, providing some dozens of channels to wired broadcasting networks. In Europe the demand may be smaller and international rather than national. Direct broadcasting satellite (DBS) services intended for reception in the home will compete with such facilities. Nevertheless, 2 programmes are already being distributed in Europe by satellite to dozens of cable networks, and this will be a growth market if satellite broadcasting direct to domestic receivers is slow to develop.

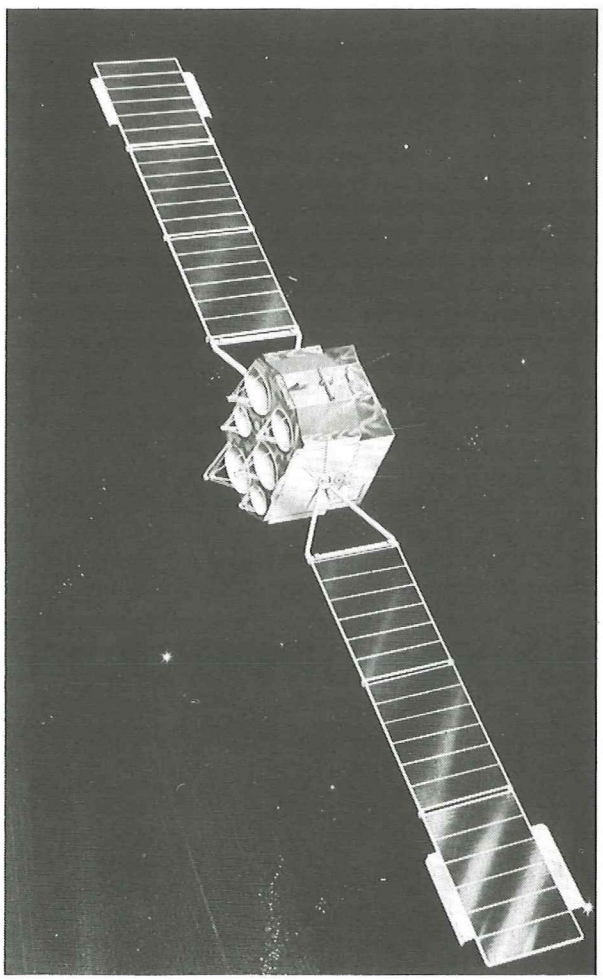
Maritime Communications

The MARISAT system was set up by a US consortium, led by Comsat, to provide satellite communication for ships and started operation in 1976. By the beginning of this year, at least 70 ships of British registration were using it, with BT connecting telephone and Telex calls to and from ships via the coast earth stations in the USA and Japan.

However, an international organisation, INMARSAT, has now been established to operate such services, and has taken over MARISAT satellite facilities. INMARSAT is also renting 2 MARECS satellites from ESA, and maritime service packages on several INTELSAT satellites, to complete its world coverage. A coast earth station at Goonhilly started operations with the Atlantic INMARSAT satellite earlier this year. Eventually, a large part of the communication service with ships in distant waters will be by satellite.

North Sea Communications

The UK does not generally have the problem of geographical barriers, but one important group of BT's customers is cut off from the rest of the country by a formidable barrier. Some of the oil-production platforms in the North Sea are 200 km from land, and BT connects them to shore by tropospheric-scatter radio links. In the relatively crowded oil-production fields now



An artist's impression of the ECS in orbit

being developed, the facilities and the cost of the tropospheric links can be shared between several platforms. Satellite communication would be an interesting alternative if more isolated production wells were drilled elsewhere on the Continental Shelf, and they might be the only satisfactory solution at greater distances from shore if, for example, oil was found to the west of Scotland.

New Office Methods

Perhaps the most topical of all satellite prospects in Information Technology Year concerns new office methods and practices in the handling of data, which demand extensive, flexible and cheap digital transmission systems. Most of these services will soon be carried within the UK in the terrestrial digital network with access to some international connections via digital facilities in the INTELSAT and EUTELSAT systems and the newly emerging digital, submarine cable systems. However, where data speeds above 64 kbit/s are required for short-periods, typically for videoconferencing or data transfer, the terrestrial network may not be able to cater economically for many years. These limitations present satellites with a vital role.

Low-cost earth terminals with small antennas can be set up at or near the users' premises and linked by satellite. Such systems have been used in the USA, where geography tends to favour satellites, for the past 10 years to provide small private networks for government and big corporations. Last year Satellite Business Systems (SBS) opened a sophisticated and flexible digital satellite system. Similar facilities will come into service in Europe at the end of next year. In the short term it is not feasible to create a single worldwide system of this kind and it will be necessary, for example, to interconnect local networks by means of long-distance trunk satellite or digital submarine-cable connections. Such systems have their economic, technical and aesthetic problems, but these new satellite services are coming to the UK, and a beginning has already been made. The European Orbital Test Satellite (OTS) is proving a useful testbed for experiments and preoperational demonstrations.

RESEARCH

The BT Research Laboratories and its counterparts in France, West Germany and Italy have been conducting a series of test transmissions via OTS as part of the process of developing the standard European 2 Mbit/s videoconferencing system. The process has been successful, providing clear evidence of the value of videoconferencing as an aid to business. Further test exercises will follow when production versions of the data-compressor code are available.

High-definition facsimile links were demonstrated between the *Financial Times* office in London, OTS and the printers of the paper's international edition in Frankfurt. Results were excellent, offering an alternative to the terrestrial data link regularly used for this remote printing. Transportable earth terminals have been used to send and receive full-definition television signals on many occasions, one memorable occasion being the Royal Wedding last year. More usually they permit an outside broadcast to be made in real time from a remote site, or provide a video connection for remote participants in a conference.

Plans are being made for an extended demonstration this year of communication between a North Sea oil-production platform and the shore by using OTS. And regular transmissions of daily television programmes offered by Satellite Television Ltd to specified cable-television companies on the Continent are just beginning.

The OTS has been in orbit for nearly 5 years; it will not go on forever and it operates in frequency bands that are subject to interference from other services. However, much is being done to provide for regular operation of small-dish

A small dish antenna being lifted onto the roof of the Financial Times' building in London

services which BT will market as *SatStream*. The main emphasis is on facilities for international services, but domestic use will also be available.

Agreement has been reached with SBS for access for British customers to the SBS small-dish network in the USA via transatlantic links in INTELSAT. If given approval by the US authorities, this new facility will open soon. Initially, it will be limited to medium-speed data channels, but work is in progress to extend the service offering high-speed data and videoconferencing.

The ECS satellites are suitable in most respects for use by small-dish earth terminals in Western Europe, but they transmit in a frequency band where interference will be a problem. However, EUTELSAT has recognised that proper provision must be made for these services. It has been found feasible to add 2 transponders designed to transmit in the preferred frequency band to 4 of the first 5 ECS spacecraft, and the first should be in service around the end of 1983. The small-dish transponders will be used in the frequency-division multiple-access (FDMA) mode, which allows large numbers of different earth stations to pass their signals through the transponder simultaneously, each on its own frequency.

France is setting up a satellite called *TELECOM 1*, which will provide a small-dish satellite system operating in the TDMA mode, like SBS. It is designed primarily to meet the needs of the office of the future, data and of teleconferencing. Its coverage zone is primarily France, but there is substantial overspill into neighbouring countries, including the UK, and this offers another opportunity for British firms needing modern communication links with the Continent. EUTELSAT is negotiating with the French administration for international use of some of the capacity of TELECOM 1 and the UK will get its share.

These European satellite facilities, becoming available around the end of 1983, will use earth terminals typically with antennas about 4 m in diameter. For cost reasons, these will usually serve a business locality rather than a single customer, and BT is developing the necessary equipment.

The ECS and TELECOM 1 facilities will get regular small-dish satellite services started in Europe. It seems virtually certain that growth will be needed in the mid-1980s, but it is not yet clear what form this growth will take.

Direct Broadcasting Satellites

On a broader front, the Home Secretary earlier this year announced that the UK was going into satellite broadcasting.

The same day, British Aerospace, GEC/Marconi and BT announced plans for a joint venture company called *United Satellites Ltd.* and a new family of satellites called *UNISAT.* These would provide 2 channels of direct broadcasting and additional capacity for small-dish services. The aim is for a first launch in late-1985.

FUTURE ROLE OF SATELLITES

In looking to the place of satellites in international communication 10 years ahead, note must be taken of the prospects of the terrestrial competition, and more particularly submarine cables. For straightforward A-to-B communication, basically telephony, cables are still important, and the coming of optical-fibre cables will give them a new lease of competitiveness. BT will continue to depend mainly on cable for access to Europe. It will start laying optical-fibre cables in the North Sea in 1984 and all its new European cables from 1986 will use this new medium. Telephone cables will break into the Indian Ocean for the first time in the second half of the decade and optical-fibre cables will cross the Atlantic and Pacific towards the end of the decade.

Satellites will continue to be important in international communication, but the headlong growth of the past 17 years will tail off before 1990. It could be that INTELSAT VI will be the biggest satellite that INTELSAT ever needs, with further evolution being aimed at cutting the cost of circuits by making better use of the facilities a satellite of given mass and power can provide.

However, even if the basic INTELSAT and EUTELSAT functions are eroded in the 1990s by the submarine-cable medium, the geostationary orbit seems bound to remain a very busy place. Mobile users—ships, aircraft and, perhaps, land vehicles—will become more dependent on satellites for both communication and navigation.

The use of satellites by developing countries to provide the backbone of their domestic trunk networks seems bound to grow. In developed countries with more sophisticated needs, small-dish satellites will be found to be indispensable for the new business services that the earth-bound media are not nimble enough to cope with economically. Satellite broadcasting is also bound to grow.

Book Reviews

Micro's For Managers. W. S. Jones, and R. C. Peattie. Peter Peregrinus Ltd. ix + 158pp. 111 ills. £9·00.

With the increasing use of microprocessor-based equipment, both domestic and commercial, it is becoming necessary for engineers and managers at all levels to gain an understanding of what these new techniques have to offer. Both users and potential manufacturers of equipment embodying microprocessor elements may have found a disturbing lack of practical information on devices and techniques in the technical press. Articles catering for seasoned engineers of microsystems or giving glowing reports of completed systems and their capabilities tend to be written. Between these 2 approaches there lies a huge gap in the information necessary to implement and use microprocessor and microcomputer-based equipment.

In this book, based on a series of seminars arranged by the Institution of Electrical Engineers for the Department of Industry's MAPCON programme, the entire process of microcomputer product development is covered. An introduction to basic principles and jargon is followed by valuable advice on how to form a project team. Both of the authors seem to have a sound practical knowledge of the pitfalls confronting potential entrepreneurs in this field, and stress the need for close project control. They give clear descriptions of project staging and protection of the considerable investment involved. The book ends with 2 chapters, on specific case studies and a variety of applications, from which useful lessons may be learned.

The overall level of explanation is pitched at any manager who is required to undertake control of a microcomputer project. No previous knowledge of electronics or computing on the part of the reader is assumed, and no attempt is made to confuse him with detailed microsystems design techniques, which are best left to the appropriate engineers. The information and sources given in the chapter on project management and in the appendices are well up-to-date, and should allow fairly detailed assessments to be made of the investment and preparation necessary for a project of virtually any size.

Although this book is aimed at the first-time project manager in microcomputing, it has much to offer those already some way along the line; it also provides a fascinating insight for the end user into the techniques of product development.

J. E. OWEN

Advanced Infrared Detectors and Systems. IEE Conference Publication No. 204. Institution of Electrical Engineers. v + 138pp. 153 ills. £21·00.

This book contains the texts of the 24 papers presented at the International Conference on Advanced Infrared Detectors and Systems held in London in October 1981. The topics covered included scanned imaging systems and their associated detectors, detecting cooling, staring arrays, 3–5 μm systems and automatic data processing.

The advantages and disadvantages of working in the 2 infrared bands currently being actively researched in 8–14 μm (good image quality at the expense of fairly complex cooling systems) and 3–5 μm (moderate image quality but requiring relatively simple thermoelectric cooling) were discussed by a number of authors. The design of detectors for each band was dealt with in detail and, since the work in this area is motivated by the need to manufacture practical systems for surveillance, and missile tracking etc, the aspect of detector cooling was considered by many authors. In addition, as far as security considerations would permit, the problems of target detection and image processing were discussed.

Owing to the specialised nature of some of the papers, these proceedings are likely to be most relevant to those working in this field; however they could be of use to those with a more general interest in the status of current research in infrared detectors and imaging systems.

R. C. BOOTH

Accelerated Ageing Tests for Connectors and Terminals

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UDC 621.315.683.001.4

This article discusses the fundamental factors that should be considered when a system of accelerated ageing tests for connectors is designed. It also describes the environmental tests that British Telecom Research Laboratories have developed for testing connectors used in the external cable network.

INTRODUCTION

Accelerated ageing tests in some form or another are used universally by telecommunications administrations (PTTs) to test electrical connectors for use in telephone networks. These tests simulate a service life of 25–40 years. In general, they are based on empirical considerations which are, at best, a close approximation of the real environment, but, at worst, are meaningless. Furthermore, the tests are sometimes modelled on the capability of the equipment that was available when the system was first devised and not on fundamentally relevant parameters.

In certain cases, the performance of the equipment is the limiting factor in the test. For example, some elevated-temperature cycling cabinets have a controlled humidity facility, but others do not. Similarly, some cabinets cannot operate at more than 2 cycles per day, whereas others can perform 20 cycles per day. Clearly, for the same number of cycles (to the same temperature limits), the degrading effect on connectors for one test is significantly different to another.

In these circumstances, it is difficult to specify a single regime of tests that is truly representative of service life. In fact, different PTTs specify totally different parameters (temperature limits, humidity etc.) for their ageing tests[1]. The situation, then, is complicated and the engineer who wishes to carry out realistic environmental testing is in a dilemma as to which test to choose from the vast array available.

CONNECTORS IN THE EXTERNAL NETWORK

Telephone cables made of copper have been used in British Telecom's (BT's) network since before the turn of this century. As a material, copper is stable and can be reliably jointed by a number of techniques including twist jointing, screw termination, soldering, crimp termination and wire wrapping. Much expertise and experience have been gained over the years of these jointing techniques and all of the above methods can still be found giving satisfactory service in the network.

Aluminium cable was introduced into the network over a decade ago for economic reasons during the period when the price of copper was at a dramatically high level on world markets. Although its electrical properties are comparable to copper, aluminium has proved more difficult to join, and it has been necessary to develop new jointing techniques. The reactive surface properties and the adverse creep and stress relaxation behaviour[2] make it difficult to terminate. For example, in normal cases, it is impossible to joint aluminium conductors by using a screw terminal or by twisting them together. The deformed material physically relaxes over a short period of time, giving rise to prohibitive values of contact resistance.

It has been necessary, therefore, to develop connectors that can be used successfully with both aluminium and copper conductors. Currently, there are 2 types of crimp connector designed to fulfil these needs in the network (see Fig. 1). They are an in-line crimp used in conjunction with an automatic jointing machine, and a butt termination used with a hand tool.

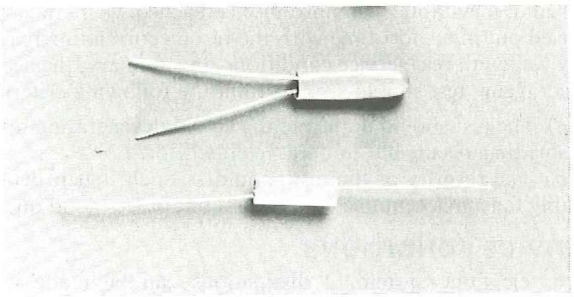

FIG. 1—Crimp connectors

Terminating aluminium cable at both the exchange and the subscribers' end of the local network still remains a problem. The difficulty is overcome by jointing on to the aluminium an extra length of copper conductor (using a crimp connector) which is then terminated by the standard techniques of wire wrapping (at the exchange end) and screw termination (at the subscribers' end).

British Telecom Research Laboratories (BTRL) are engaged in a continuous programme of development of new connection systems for the network. These systems include both in-house products as well as the assessment of proprietary devices, most of which need to be modified to work satisfactorily with aluminium. At present, more than 5000 prototype devices covering the full range of connector designs are evaluated each year. A lot of effort has been directed recently towards the design of insulation displacement connectors (IDCs)[3]. These devices are quick and easy to install and, technically, have potential for making joints with good electrical performance on both aluminium and copper conductors.

ACCELERATED TESTING

When setting up a test system, it is necessary to understand the detailed nature of the operating environment and the processes that will degrade the integrity of the contact. Factors such as temperature fluctuation, humidity levels, vibration effects and atmospheric pollution must all be considered. However, this is no easy task, because joints can be situated in any location above or below ground and so experience a random range of environmental conditions; for example, the humidity conditions inside a joint, depending on the amount of trapped moisture, may be quite different to the surrounding air. In view of this diversity of operating conditions, it seems reasonable to base ageing tests on the "worst-case" situation.

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The next stage is to design a suitable test or tests which will reproduce these factors in an accelerated form. These tests must be severe enough to fail unacceptable connectors, but not so severe as to fail good connectors. Deciding on a suitable failure criterion is an arbitrary decision which depends on the performance specification for the connector; for example, BT currently specify a maximum rise of 2·5 mΩ per connection over the environmental test period. In addition, difficulties inevitably arise in deciding on a suitable acceleration factor that will complete the test schedule in a short time, but ensure that the correct degradation factors are accelerated. Also, the relationship between the different types of degradation factor must be preserved because, in a service environment, a number of different mechanisms are involved with various degrees of interaction.

The design and interpretation of accelerated ageing tests is both difficult and controversial. The development of a test that satisfies all the service requirements is a monumental task and, inevitably, a compromise is reached where the test is carried out in a short time with the results correlating reasonably well with real service conditions. In summary, the accelerated ageing test should seek to fulfil the following criteria.

(*a*) The test should duplicate the actual degeneration mechanisms that occur, but in an accelerated form.

(*b*) The severity of the test should be such that it demonstrably fails unacceptable connectors, but passes good ones.

SERVICE CONDITIONS

In a telephone system, 2 distinctions can be made when operational environments for connectors are considered: inside, meaning in the telephone exchange building or subscribers' premises; and outside, meaning anywhere else. In the inside situation, the electrical contacts operate in a comparatively mild environment; that is, the temperature and humidity in the building are controlled within set limits. Typical contacts are gold- or gold-substitute-plated for optimum electrical performance and the connector body is not filled with grease and so affords little protection from the surrounding atmosphere.

The ageing mechanisms that occur on the contact surfaces are due to a combination of temperature and humidity fluctuation, and to the telephone circuitry. But, more significantly, the deterioration of the contact is due to the effects of dust and pollution in the atmosphere. This service environment is reflected in the tests that are recommended for internal gold-plated contacts; that is, the sulphur dioxide industrial atmosphere exposure test[4].

In the external telephone network, cable joints can experience the full range of outside extremes. In unprotected joints (for example, those without dry-air pressurisation) the temperature and humidity levels vary directly with the outside environment. Typically, connectors are tin-plated[5] and protected from the air by a grease barrier. In addition, the plastic body of the connector is normally designed well enough to exclude the atmosphere from the intimate contact area (see Fig. 1).

When attempting to determine service ageing factors, consideration must be given to the mechanisms that result from daily and seasonal temperature and humidity fluctuations. In the UK, a typical connector in an unprotected outside location experiences a temperature range of between −10°C to 40°C and humidity levels traversing the full 0–100% range. Any test seeking to reproduce this environment should take account of these variables and try to reproduce them in an accelerated form.

AGEING MECHANISMS

There are a number of competing mechanisms which occur in a connector operating in an external location and which result in the performance of the connector deteriorating. These are quite apart from any superimposed mechanical effects that occur because of handling or vibration.

Thermal Expansion

One mechanism is the difference in the thermal expansion between the separate components of the joint. A typical cable connector can be made up of copper, bronze, aluminium, brass and polymeric material (normally polyethylene or polyvinyl chloride (PVC)). Table 1 shows the coefficients of thermal expansion for these materials.

The components of the connector expand and contract with temperature variations causing mechanical working of the contact areas. The situation is worsened, for example, if the conductor insulation is trapped inside the joint, as in a standard crimp connection. The forces involved can be so great that the expansion of one metal part can stress an adjacent part to beyond its plastic limit, causing permanent plastic deformation. As the joint cools, the pressure on the contact surfaces reduces and allows the ingress of gas or moisture to form oxides or insulating films.

Galvanic Corrosion

Once moisture is present in the joint, the process of galvanic corrosion can occur. This degradation mechanism operates when dissimilar metals are exposed in the presence of an electrolyte. The amount of corrosion depends on the separation of the 2 metals in the electrochemical series (see Table 2).

Corrosion is caused by the electric current that flows from the anodic member, through the solution to the cathode, and any superimposed current resulting from the telephone circuitry may accelerate this process. Physical corrosion occurs as the anodic material is attacked and goes into solution from which it tends to be deposited on the cathode. Table 2 shows that as aluminium is quite electronegative relative to copper, corrosion will occur readily between them, aluminium (the anodic material) being attacked.

Stress Relaxation

A third independent degradation process is caused by creep

TABLE 1
Coefficients of Thermal Expansion for Various Connector Materials

Material	Coefficient of Thermal Expansion (per °C)
Aluminium	23×10^{-6}
Copper	$16{\cdot}7 \times 10^{-6}$
Steel	11×10^{-6}
Brass	$19\text{–}23 \times 10^{-6}$
Phosphor bronze	17×10^{-6}
PVC	$7\text{–}8 \times 10^{-5}$

TABLE 2
Electrochemical Series for Various Connector Materials

Material	Electrode Potential
Silver	+0·80
Copper	+0·35
(Hydrogen)	0·00
Lead	−0·13
Tin	−0·14
Nickel	−0·25
Iron	−0·44
Aluminium	−1·35

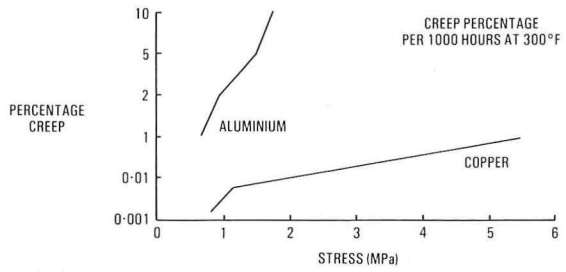

FIG. 2—Stress relaxation behaviour of copper and aluminium

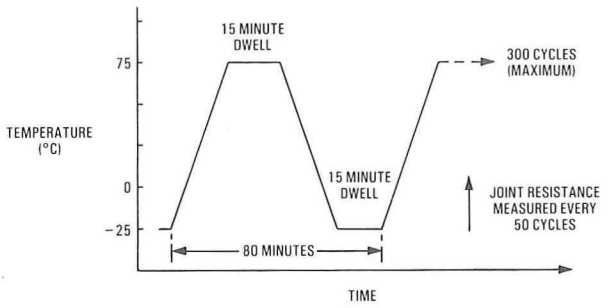

FIG. 3—Temperature cycling test

and stress relaxation of the metal parts of the connector. There is some confusion as to the separate roles of creep and stress relaxation, but both have the effect of lowering contact stresses. In general, creep is a continuing yield at a constant stress, where the yielding is a result of a slow atomic diffusion mechanism that is dependent on time and temperature. Stress relaxation is also time dependent, but is not accompanied by a dimensional change. Both creep and stress relaxation can result in a change from elastic to plastic strain which, ultimately, has the effect of reducing the contact pressures in the joint to a point where the joint may fail because of excessive contact resistance.

Fig. 2 shows a comparison of the stress relaxation behaviour of copper and aluminium. The stress relaxation rates for the 2 materials are significantly different. In fact, results have shown[2] that in copper this creep, or cold flow, ultimately decreases to a low value. Aluminium, however, yields to the stress almost indefinitely.

The above discussion has shown that creep and stress relaxation mechanisms can be expected to take place to varying degrees in connectors used externally. It is clear that galvanic corrosion and creep and stress relaxation occur to a greater extent in an aluminium joint than in a copper one, so illustrating the greater difficulty in achieving long-service low-resistance joints with aluminium conductors.

Design Factors

There are a number of design factors that can be used to reduce the ageing effects in connectors. The body can be designed so that the conductor is securely anchored at the point of entry; this reduces any deleterious effects caused by handling or vibration. A suitable design of the connector casing, together with the use of water repellant grease, can, to a large extent, eliminate moisture from the area of the contact. This slows down or stops any galvanic corrosion effects.

A further example of effective connector design is in the use of contact coatings. Tin[6] is used extensively to prolong the life of many types of connector. In fact, most connectors used with copper conductors have tin-coated contact elements. In addition, indium[7] and nickel[8] have been successfully used to improve the performance of aluminium joints.

Although the micromechanisms of protection that these coatings give are not fully understood, they have been shown to extend the life of the joints by inhibiting the formation of oxides or corrosion.

BRITISH TELECOM ACCELERATED AGEING TESTS

BTRL have developed a series of accelerated ageing tests based on the foregoing discussions. The test regime comprises temperature cycling and heat soaking in succession. Each one of these tests can affect connectors of different designs in varying ways (see Table 3), but in tandem, the degradation is suggested to be equivalent to 25–40 years of service life. The parameters of temperature limits, cycle time, and test duration have been chosen as a compromise between accelerating the correct degradation factors, and completing the test in as short a time as possible. The tests, in total, take 3 months to complete.

TABLE 3
Effect of Basic Connector Design on Performance

Type of Connector	Conductor Deformation	Performance of Connector in Service
Screw	Compressive plastic deformation	Stress relaxation in aluminium leading to reduced contact stress
Crimp	Gross plastic deformation	Gross deformation of conductor may inhibit stress relaxation. The insulation is trapped inside the connector causing breathing as temperature fluctuates
IDC	Plastic deformation at one transverse section	Stress relaxation properties of contact geometry is important because there is a relatively small area of contact
Wire wrap	Plastic deformation locally at post corners	Many local areas of good intimate contact, but tension must be maintained in wrap
Peg and tube	Gross plastic deformation (conductor smeared out)	Large contact area, but protection needed against subsequent oxidation or corrosion

Temperature Cycling

The temperature cycling test (see Fig. 3) consists of 300 cycles between −25°C and 75°C. Each cycle lasts for 80 minutes, including a 15 minute dwell at each temperature extreme. The humidity level during the test is uncontrolled.

The cycling effect promotes deterioration in the connectors as a result of the thermal expansion of the internal components. The cycle rate is chosen to be as fast as possible to accelerate this effect, but not so fast as to promote thermal shock conditions (which are unlikely to occur in the real environment).

The 15 minute dwell at each temperature extreme is considered just sufficient time for the connectors to reach equilibrium; that is, to stabilise the presence of any temperature gradients.

The humidity in the test is uncontrolled, but each cycle passes through the dew point and so ensures that moisture is deposited on the contacts. This will promote any likely galvanic corrosion or general corrosion effects.

Heat Soak

The heat soak test consists of 100 days at 60°C. The test

ensures that any high-temperature effects such as creep and stress relaxation are promoted. The upper temperature limits in this test and the temperature cycling test were chosen to be as high as possible without causing damage to the plastic casings of the connectors.

MEASUREMENT TECHNIQUES

The test connectors are mounted 20 at a time on the measuring boards (see Fig. 4), which are pre-wired so that the contact resistance of each connector can be measured. For measurements, the board is plugged into the resistance measuring equipment by a standard edge connector.

The resistance measuring equipment (see Fig. 5) consists of a precision voltmeter, a constant-current source and a data logger. In operation, a controlled current of 100 mA is passed initially through the series-wired connectors. Subsequently, the data logger selects each connector in turn so that the voltage drop across the joint can be measured. The joint resistance is a combination of the bulk material resistance and the contact resistance. This measured value is, in itself, not important because the lengths of conductor feeding the joint can vary from one connector to another. Rather, it is the change in the value of the resistance over the test period that is a measure of the contact performance.

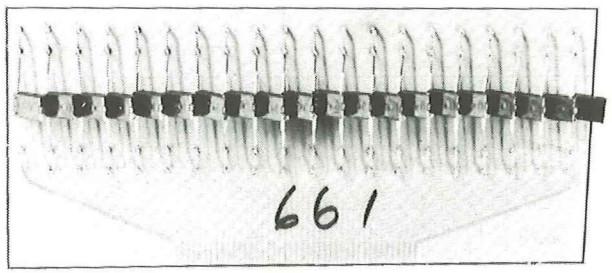

FIG. 4—Connector test board

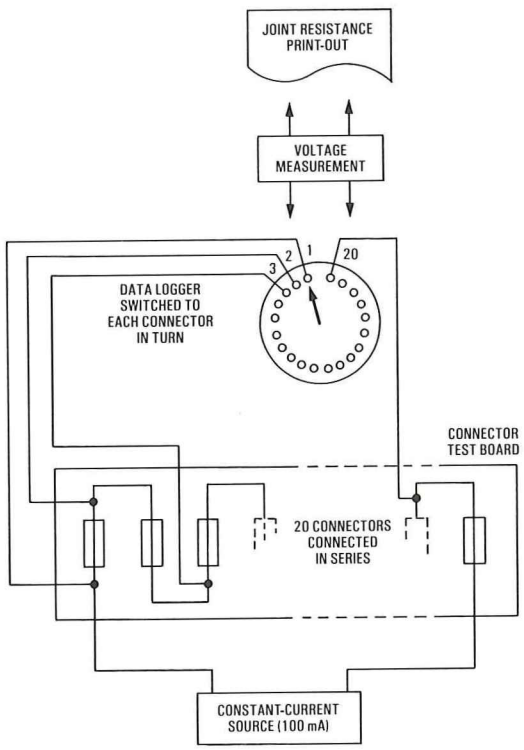

FIG. 5—Operation of resistance measuring equipment

The resistance of test connectors are measured at the start, and then at intervals during the test. During temperature cycling, boards are measured at 50-cycle intervals, and during the heat soak tests, at 25-day intervals. Prior to taking measurements, the boards are allowed to reach equilibrium at 20°C.

RESULTS

Typical test results for a variety of connector types are presented in Figs. 6–10 and are a selection of the many environmental tests that BTRL have done. In most cases, the connector test boards have been subjected to both temperature cycling and heat soaking in succession, but some early results are included for when only temperature cycling was available.

Each plotted result is the arithmetic mean of the joint resistance of 20 identical connectors on a board. For clarity, the scatter in the result has been omitted. In general, the connectors that showed a small rise in contact resistance over the tests had very little scatter. However, those connectors that showed a large increase in contact resistance had a wide scatter band.

Present BT test methods are such that prototype connectors are initially tested in batches of 20. Then, if future use is possible, a much larger statistically-meaningful number of connectors are subject to test.

Fig. 6 shows results for a 0·5 mm diameter aluminium conductor connected under a brass screw. The initial joint resistance of 8·5 mΩ increases rapidly to 19 mΩ after 212 cycles. This appears to be a classical demonstration of aluminium stress relaxation under a screw termination. Earlier discussions have indicated how aluminium does not work satisfactorily under a screw connection because, in service, it stress relaxes until the contact resistance becomes prohibitive.

The results for crimp type joints of both the in-line and butt termination variety are shown in Fig. 7. Referring to the butt termination results (boards 2 and 3), there is a significant difference between the joints connected with aluminium and those with copper. On first analysis this is suggested to be due to the mechanism of stress relaxation in the aluminium wire. However, the situation is complicated because the results for the in-line termination (boards 4 and 5) show no such difference between aluminium and copper—both results are good.

This contrast may be the result of the higher stresses that are generated in the machine jointed crimp producing more plastic deformation in the conductor. The distribution of stresses in the conductor would be of such complexity that a

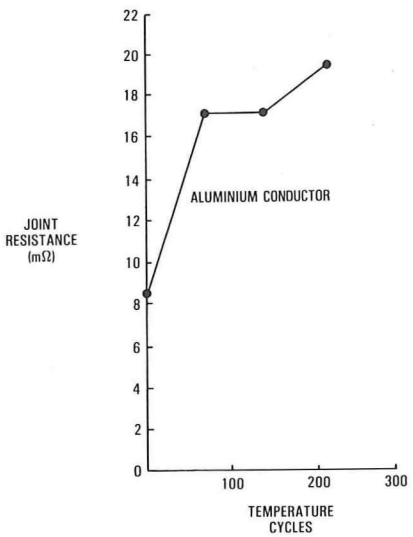

FIG. 6—Results for screw terminal connections

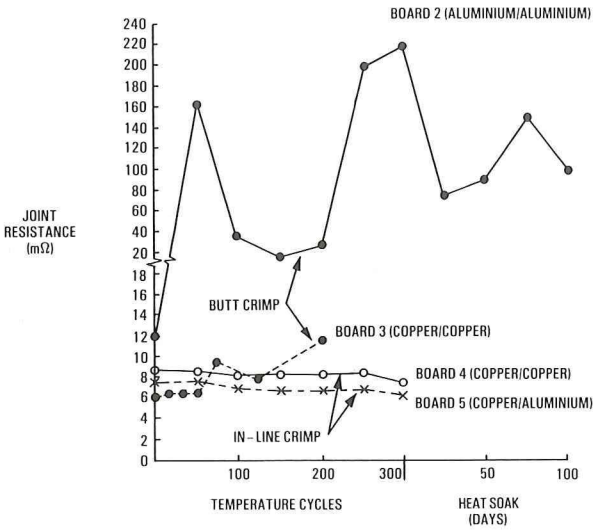

FIG. 7—Results for crimp connections

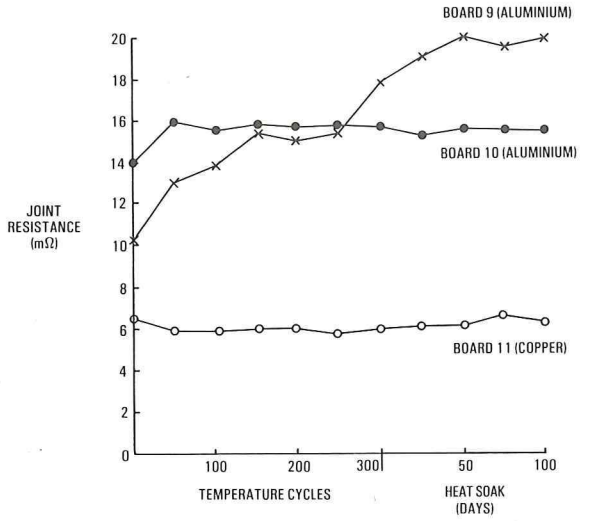

FIG. 9—Results for wire-wrap terminations

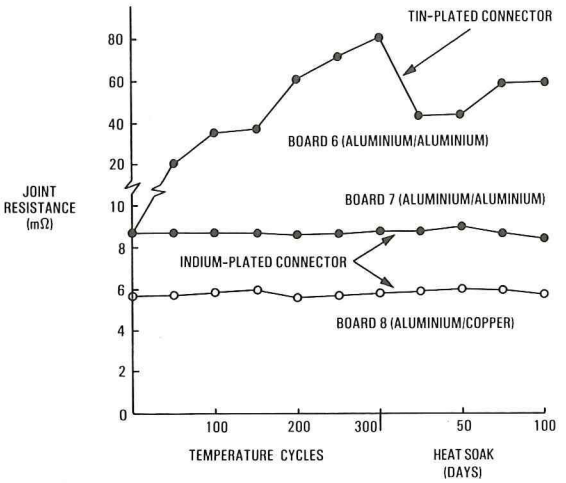

FIG. 8—Results for insulation displacement connectors

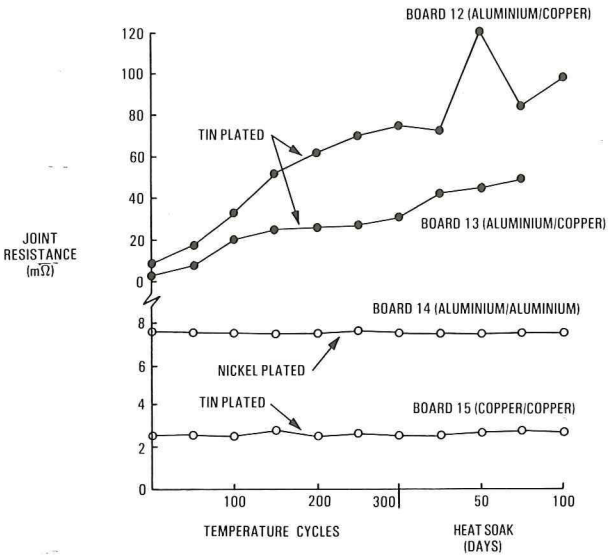

FIG. 10—Results for peg-and-tube connections

small amount of relaxation would not reduce the stresses significantly.

Fig. 8 shows some test results for IDCs. Recently, much development has been carried out on these types of connector to ensure compatibility with aluminium conductors, because early types of IDC were designed to operate on copper only. Boards 7 and 8 show results for connectors where the contact element has been coated with indium to improve contact properties. The results are good, showing little increase in contact resistance over the test period.

In contrast, board 6 shows unacceptable results for aluminium conductors jointed in an IDC that had been tin plated for use with copper. Presumably the aluminium in both the good and the bad IDCs experienced stress relaxation to the same degree and the temperature cycling would have caused a similar thermal expansion mismatch at the respective contact faces. It was evident, therefore, that the indium protected the area from oxidation or galvanic corrosion.

Results for wire-wrap termination are shown in Fig. 9. Boards 9 and 10 are results taken at successive steps in the research trial to develop a suitable wrapping tool to wire wrap aluminium conductors[9]. The board 9 result is from an early stage of the trial during which insufficient tension was applied to the wrap. Consequently, the contact resistance rose to unacceptable values because the stress relaxation was sufficient to degrade contact performance. Board 10 shows a later result obtained with an improved wrapping head; the wrapping tension appears to be sufficiently high to compensate for any stress relaxation that may have occurred during the environmental tests. Finally, a standard copper wire wrap (board 11) is shown for comparison.

Fig. 10 shows the results for a peg-and-tube type connector. These connectors operate on the principle of a peg, forced into a tube, which simultaneously smears out the trapped conductor. This jointing action spreads the conductor over a large surface area, which, theoretically, gives a high contact integrity. It is necessary, however, to protect the large contact area from oxidation, and this is provided for by using 2 types of connector coating: tin for copper wires, and nickel for aluminium wires.

The results in Fig. 10 are for joints which were connected both in the recommended and non-recommended way. As expected, boards 12 and 13 show unacceptable resistance increases for aluminium jointed in a non-recommended tin-coated connector. Boards 14 and 15, however, connected in the correct combination, are satisfactory. These results again demonstrate the protective capabilities of suitably selected coatings.

CONCLUSIONS

BTRL have developed an environmental test schedule to assess the service performance of external connectors. The schedule has been developed after consideration of the fundamental degeneration processes that occur in practice. The tests, consisting of temperature cycling and elevated heat soaking in tandem, are considered to give results which are equivalent to 25–40 years service life.

Results have been presented for a variety of connector types. These show that service conditions appear to be accelerated to an extent where a clear distinction can be made between good and failed connectors. However, it is accepted that the science of accelerated ageing is complicated, because, in service, many little understood interactive processes occur. In summary, the BTRL test results show a good compromise between quick, and realistic results.

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Book Review

Handbook of Microwave Testing. Thomas S. Laverghetta. Adtech Book Company. 515pp. 199 ills. £25·00.

This book is a very good introduction to the instrumentation and measurement techniques that are used in the microwave field. The author's intention when he wrote this book was "to remove the idea of complexity and make the measurements understandable"; and in this he has succeeded. Although the text is at times laboured, it is well written, and the diagrams are clear.

Chapter one indicates the areas that must be considered in order to produce the correct tests for a given requirement, and is applicable to anyone involved in experimental measurements in any field, not just microwaves. These areas include: knowing which parameters are to be measured; making the proper test set-up; knowing how a device is to be tested, and how the results are to be interpreted when they are received.

The chapter on test equipment covers 4 main areas as follows:

(*a*) *Signal Generators* continuous wave, swept and synthesised;

(*b*) *Indicating Devices and Signal Detection* power meters, spectrum analysers, noise figure meters, counters;

(*c*) *Auxiliary Components* attenuators, directional couplers, slotted lines, normalisers, modulators; and

(*d*) *Systems* including PM1038 and HP8410 network analysers.

Other chapters deal with power measurements, noise measurements, antenna measurements and procedures for measuring active devices.

Chapter 5 contains detailed discussion on one of the most valuable pieces of microwave test equipment—the spectrum analyser. It covers basic frequency-domain theory and illustrates how the analyser can be used for power, frequency and noise measurements. Receiver measurements are also covered and include modulation (amplitude modulation (AM), frequency modulation (FM), and combined AM/FM), pulsed radio frequency (RF) measurements and distortion measurements. The specifications that make a "good" spectrum analyser are discussed so that data sheets for analyser units can be understood and the correct choice for an individual's requirements made.

Chapter 8 provides a very detailed examination of the IEEE's 488 interface standard and its use for automatic microwave testing. Every page of the standard is presented in plain English, and this will be helpful to those who wish to adapt a particular set-up to the interface system.

In fact, this is the theme of the whole book: to explain the principles so that they can be adapted to suit particular requirements, although specific examples are included for clarification. The pitfalls that can be encountered and the errors that can result if care is not exercised in the design of a measurement bench are also highlighted, and methods suggested for alleviating them.

I would recommend this book as suitable reading for laboratory technicians and potential microwave engineers; it could also still be read with benefit by practising microwave engineers.

B. L. CLARK

Inland Network Strategy

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UDC 621.395.74.001.1

Modern society increasingly requires sophisticated interactive telecommunications and it is vital for British Telecom to be ready to meet the rapidly changing telecommunications needs of business and society generally. An essential prerequisite is an effective coherent strategy for the development of the inland network. This article identifies the potential demand for services and outlines the basic strategy for the development of the network.

INTRODUCTION

Modern society depends heavily on the dissemination and interchange of information in audible and visible forms. Much of this communication is one-way through newspapers, periodicals, broadcast radio and television etc., but there is a rapidly increasing demand for sophisticated interactive telecommunications.

The telecommunications business of British Telecom (BT) has historically been dominated by the public switched telephone network (PSTN), but, in recent years, a progressively increasing range of voice and data services has been provided and has gone some way towards meeting the evolving telecommunications requirements of both business and residential customers. However, as a result of the increasingly diverse applications of modern technology, the telecommunications needs of business and society generally are changing rapidly. It is therefore essential to have an effective coherent plan for the development of BT's inland network which exploits modern technology for the benefit of customers.

This article starts by identifying the principal needs of customers and the potential demand for network services; it then describes the basic strategy for the development of the inland telecommunications network.

CUSTOMER NEEDS AND NETWORK SERVICES

Business customers range from those with only one or a few connections (with simple PBXs), heavily dependent on BT's network and services, to those with large PABXs having sophisticated facilities, private-circuit networks, and many BT exchange connections carrying high levels of traffic. Residential customers, who generally have single exchange connections, require simple facilities, and generate low traffic.

An effective and responsive telecommunications network is essential to the efficiency of the UK's business sector, and it is important that the plans for BT's inland network match the needs of business customers. Of particular importance are speed of provision of service, acceptable cost, a quality of service satisfying customer expectation, a responsive interface between the customer and BT, and an evolving range of voice and non-voice services and facilities that meet emerging needs. Residential customers are often less demanding in respect of their service requirements and their ability or willingness to pay is less, but generally their needs can be similarly summarised.

So far as business customers are concerned, 2 aspects have become of particular importance in recent years:

(*a*) The growth in demand and variety of non-voice services, including conventional data transmission involving computers, text transmission between a variety of advanced keyboard terminals, facsimile transmission, electronic funds transfer systems, and many other varieties of traffic of the emerging "information society". A large part of this information is most efficiently conveyed in digital form.

(*b*) The development and growth of private communications networks, separate from (although frequently interconnected with) the public switched services. These private networks are carrying an increasing proportion of traffic that is best conveyed in digital form.

Service growth in the residential sector is most likely to occur in information services, home shopping/banking, security and alarm services, and in multichannel video distribution for entertainment requirements.

A recent study of the total potential revenue from providing telecommunications services that could be available to BT and its competitors forecasts very rapid growth in some sectors but continued dominance of the telephony service, as illustrated in Table 1.

The primary need is to provide a sound communications "transport" system for the wide range of information to be carried, a task that is facilitated by the current economics of transmission using digital techniques.

Comments on each service sector, against the background of Table 1, are as follows:

(*a*) *Telephony* (*Speech*/*Voice*) *Services* These will remain dominant through the 1980s and beyond. There is a need to ensure a more consistent quality of service over the range of customers and calls; to develop existing and provide new supplementary services; and to provide voice-storage/message transmission services.

(*b*) *Data Services* The business customer increasingly requires a wider and more sophisticated range of data services, together with a comprehensive range of interface capabilities to facilitate connection of the wide range of specialised terminal devices now available. The role of the inland network is likely to be increasingly the provision of socket-to-socket services for the transfer of electronic data between a range of standard interfaces, with a growing demand for higher data rates and rapid response. There will be important complementary roles for the packet switched data service (PSS), digital private circuits and (starting in

TABLE 1
Potential Inland Network Growth

Service Sector	Growth 1984–1994 (percentage)	Sector Distribution 1984 (percentage)	Sector Distribution 1994 (percentage)
1 Telephony	35	85	72
2 Data	400		
3 Text	150		
4 Visual	300	15	28
5 Mobile	400		
6 Private Circuits	60		

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London in 1983) a circuit-switched digital data service offering a range of data rates.

(*c*) *Text Services* The physical transmission of hard copy is relatively slow and costly, while the potential of Telex is limited. The way ahead is clearly communication between word processors with Teletex becoming the normal standard. Standardisation of the service features and protocols will enable the transmission of text, primarily by business customers, to be readily accomplished. There is likely to be increasing use of Teletex (with service starting in 1982/3), high-speed facsimile, mailbox services, communicating word processors and other electronic-office devices resulting in increasing use of the telecommunications network.

(*d*) *Visual Services* There is a growing and potentially large market for visual services. The major element is likely to be cable television, but there will also be some demand for switched wideband (for example, 2 Mbit/s) low-definition picture services.

(*e*) *Mobile Services* In the immediate future, the increasingly sophisticated needs of itinerant customers, when they are away from their normal business or residential telephones, must be recognised and met by enhanced radiophone, radiopaging and other radio services, and by improving services from public call offices and renters' payphones. In the longer term, the concepts of personal telephone numbers (rather than numbers identifying locations) and personal cordless telephones will undoubtedly come together and will be dependent on an intelligent national (and possible international) telecommunications network capable of following a customer as he moves from location to location.

(*f*) *Private-Circuit Services* It is anticipated that analogue and digital private-circuit services will grow in importance and be subject to aggressive competition. For large businesses, private-circuit services are an essential element of their communications networks and the rapid provision of circuits having the right capabilities at acceptable prices is essential to commercial success. BT can also earn revenue by supplying circuits to organisations offering specialised value-added services to the public.

(*g*) *Other Services* The rapid growth of a diverse and incompatible range of communicating word processors and other electronic office equipment is resulting in a need for protocol and format standardisation. As a consequence of the wide range of current and emerging text services and protocols, the BT networks will need to cater for effective interworking between a range of standards.

BASIC STRATEGY

The basic strategy is to manage, modernise and develop the inland telecommunications network:

(*a*) to improve the quality of service (for example, give better transmission performance, improve call-failure rate, reduce call set-up time),

(*b*) to be market responsive, developing existing services and providing new services and facilities to satisfy emerging customer needs, and

(*c*) to minimise costs.

The existing network of analogue transmission systems and space-division switching is a well established means of providing basic telephony services and a number of derived services such as Datel, Prestel and Radiopaging, together with access to more specialised services such as the PSS. However, much of the equipment used in the existing network is relatively expensive to provide and maintain, lacks flexibility for service changes or enhancements, and offers relatively low transmission capacity and, by modern standards, poor response times,

An integrated digital network (IDN) of digital transmission, stored-program controlled (SPC) digital circuit-switching, and separate-channel signalling systems linking all local exchanges (or concentrators) is the essential prerequisite of a minimum-cost evolving telecommunications system exploiting modern technology. The value of the provision of integrated digital switching and transmission was demonstrated in earlier studies, and recent calculations have confirmed that, given a wholly digital network, future network annual charges will be halved. Stored-program control and common-channel signalling provide the basis of an intelligent network and a range of customer services. The complementary elements of the basic strategy comprise the conversion of the main network of transmission systems and trunk exchanges, together with the director area tandem networks, to digital operation by 1992, and the deployment of digital local exchanges to those customers who will place the highest value upon their capabilities and derived services.

The IDN can be progressively extended to customers' premises over the existing 2-wire local distribution network, in response to their needs, to create a multi-purpose integrated services digital network (ISDN). Until such a multipurpose ISDN is available throughout the UK, the needs of most customers will continue to be met by the specialised application networks, all of which make use of the common transmission network.

TRANSMISSION NETWORK

In order to realise the potential economies of scale and to minimise the problems associated with forecasting needs some years ahead (to allow for lead times in plant procurement), it is important for all the specialised application networks (PSTN, Telex, PSS, etc.) to use a common transmission network with plant dedicated as necessary to the individual application networks. The plan is to convert the main network of transmission systems, together with the director-area tandem networks, to digital operation by 1992; the resulting progressive penetration of digital trunk and junction transmission systems is shown in Table 2.

Substantial quantities of 2 Mbit/s, 8 Mbit/s and 140 Mbit/s digital transmission and associated multiplexing equipment are already planned and are progressively coming into service, increasing use being made of transverse-screen cables, new radio systems and optical-fibre cable. Particularly during the early years, the deployment policy for digital transmission plant is vital and the first priority is to link the major commercial centres and thus support the deployment of System X, the extension of the PSS, and digital private circuits.

While the main thrust of converting the transmission network to digital operation is well established, some important technical issues remain to be resolved, particularly the role of satellites and local wideband distribution networks.

So far as satellites are concerned, studies confirm that for traditional point-to-point transmission within the inland network they are not economic compared with cable and terrestrial radio systems. Technical developments will undoubtedly reduce the cost of basic elements of satellite systems, but experience suggests that the cost of terrestrial systems will also further reduce. There does, however, appear to be a significant role for satellite circuits where their particular advantages (namely, mobility, short lead time and wide bandwidth) can be effectively exploited to meet specific needs within the BT and customer networks.

TABLE 2

Progressive Penetration of Digital Trunk and Junction Transmission Systems

Type of Circuits	1981–82 (percentage)	1986–87 (percentage)	1991–92 (percentage)
Analogue (Cable and Microwave)	98	72	19
Digital (Cable, Microwave and Optical Fibre)	2	28	81

INTEGRATED DIGITAL NETWORK DEVELOPMENT AND STRUCTURE

As already indicated, the principal elements of the network strategy are the conversion of the main network of transmission systems and trunk exchanges to digital operation by 1992; and the provision of a digital exchange presence at all large local exchanges in parallel with the elimination of all Strowger large local telephone exchanges from the network similarly by 1992.

Digital Network Programme

The highlights of the System X and digital-network programme are shown in Table 3.

Central to the programme is the intention that the deployment of System X should be market led, with priority being given to the 30 principal commercial centres listed in Table 4.

The objective is for the IDN to link these 30 centres by 1985 and to provide the enhanced services for their customers, particularly business customers, that are made possible by System X.

Deployment of Modern Local Exchanges

The target date for completing the replacement of Strowger local telephone exchanges by modern systems is 1992 for large exchanges and 1995 for small exchanges.

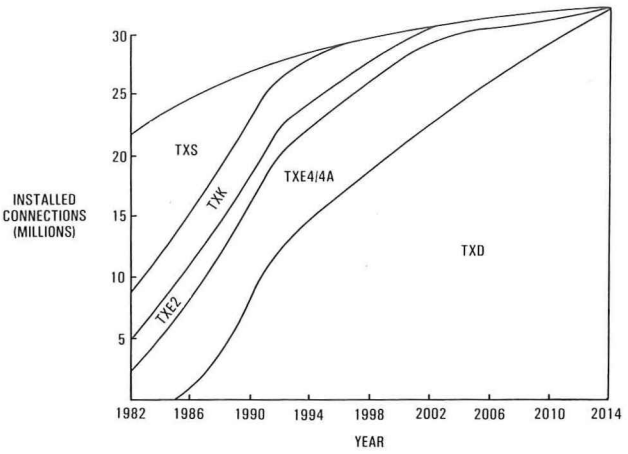
The progressive conversion of all local exchange connections to digital operation is illustrated in Fig. 1.

TABLE 3
System X and Digital Network Programme

Date of First Introduction	Application
1980	Junction tandem exchange
1981	Medium-sized local exchange Operations and maintenance centre Trunk exchange
1982	Local exchange concentrator Small digital local exchange (UXD5)
1983	Pilot ISDN service in London Large local exchange
1984	London, Birmingham and Manchester, the first cities on the fully integrated digital switching and transmission network (IDN)
1986	30 major cities linked by the IDN
1991	At least 9 million customers on System X. The bulk of trunk traffic switched on System X. ISDN capabilities available on demand in all major conurbations
1992	Strowger large local exchanges eliminated from the network. Main network and director area tandem networks completely converted to an integrated digital network

TABLE 4
Thirty Principal Commercial Centres

1 London	16 Outer Metropolitan South East
2 Greater Manchester	17 Leicester
3 West Midlands	18 Edinburgh
4 West Yorkshire	19 South Yorkshire
5 Merseyside	20 Brighton
6 Greater Glasgow	21 Colchester
7 Outer Metropolitan West	22 Coventry
8 Outer Metropolitan North	23 Teeside
9 Avon	24 Belfast
10 Tyneside	25 Reading
11 Cardiff	26 Southampton
12 Preston	27 Oxford
13 Outer Metropolitan East	28 Stoke
14 Outer Metropolitan South West	29 Portsmouth
15 Nottingham	30 Milton Keynes



TXS: Strowger
TXK: Crossbar
TXE2: Electronic (small)
TXE4/4A: Electronic (large)
TXD: Digital

FIG. 1—Conversion of local exchanges to digital operation

During the past decade the available crossbar and reed-electronic modern local-exchange capacity has been directed almost exclusively towards replacing Strowger exchanges with the objective of improving the quality of service experienced by all customers, the worst service cases being accorded highest priority. Virtually all Strowger exchanges qualifying for priority treatment have now been programmed for replacement.

In the future, however, the local-exchange modernisation strategy will be directed towards providing the maximum commercial benefit to BT. A recent review of the strategy has led to the conclusion that available System X local exchange equipment should primarily be deployed to serve business-customer conurbations, the size of each System X exchange installed being decided, as far as practicable, by commercial considerations of incremental revenue and operational costs. The TXE4A cost-reduced reed-electronic large-local exchange equipment now becoming available will, as a consequence, be deployed to meet the residual need for Strowger large-exchange replacement after System X plans have been taken into account; this will mean that it will be used primarily to serve the residential market.

The provision of new crossbar and small electronic (TXE2) exchange systems will reduce progressively as growth is provided by System X.

Network Structure

The United Kingdom Trunk Task Force[1] concluded some years ago that an all-digital network having a significantly smaller number of trunk switching nodes was potentially more economical than the current network of approximately 370 nodes. Recent studies have demonstrated that minimum network cost would result from some 60 digital main switching units (DMSUs) and that appropriate restructuring of the network could overcome some operational problems (including the widespread need for inter-working equipment between all non-System X local exchanges and their DMSUs), very extensive circuit rearrangements during network digitalisation, smaller than optimum sized plant installations, and extremely difficult control of modernisation implementation.

As a consequence, it has recently been decided to adopt a new evolutionary network structure, the main features being a simple hierarchy of 60 fully-interconnected DMSUs (all of which will be installed by 1986), the separation of the analogue and digital networks, flexibility, and administrative simplicity.

Telephony Transmission Standards

Telephony transmission standards in the evolving digital network have been discussed in detail in an earlier article[2].

The IDN will result in a 2-wire-to-2-wire loss between local exchanges on all classes of connection of about 6 dB, this value having been chosen as the one that will result in all calls having a nominal overall reference equivalent that causes minimum customer dissatisfaction. This represents a considerable improvement on the present transmission plan, where the loss between 2 local exchanges (via 2 GSC-to-GSC links) can be as high as 19·5 dB.

The earlier article made reference to a number of co-existence problems during the long period of transition from an all-analogue network to an IDN embracing all local exchanges. These problems will largely be eliminated by the new evolutionary network structure referred to above owing to the manner in which traffic is confined to either the digital or analogue network with minimum interconnection.

Control of Network Modernisation

A layered management control system has been devised to ensure that the network modernisation strategy is implemented in a coherent manner. The top level consists of a network master plan (NMP), updated annually, which documents the broad plans for the various parts of the network and provides a mandatory framework for detailed planning. Specific detailed control mechanisms are being developed both to ensure that plant planning, programming and ordering conform to the NMP and to co-ordinate the installation and bringing into service of the various elements of the new network.

SPECIALISED NETWORKS

The needs of most customers now and in the future will be met by the existing and independent specialised application networks and from the integration of capabilities upon the developing digital network. These application networks supporting services of particular characteristic are being progressively modernised or enhanced, as follows.

Telephone Network

The analogue PSTN will continue to carry most of the speech-services traffic throughout the 1980s. The PSTN is now being enhanced by fast customer-to-exchange signalling using the multi-frequency MF4 system, and by the introduction of new local-exchange facilities on TXE4. It is also planned to enhance some existing exchange systems to provide:

(*a*) itemised bill facilities,
(*b*) additional telephone supplementary services, and
(*c*) if possible, a measure of digital transmission through existing exchanges.

From 1983 onwards, System X will have an increasingly important role to play in providing enhanced and new services for business customers.

Telex Network

The Telex network provides a substantial and important national and international service for the business community and it is being progressively modernised by replacing Strowger Telex exchanges by SPC switching equipment; existing transmission systems are being replaced by time-division-multiplex equipment and single-channel voice-frequency equipment. It is anticipated that phase 1 of the modernisation programme will result in about 45% of customers being served by the modernised network by 1984. It is planned to continue modernisation in at least one further phase by 1986, when 66% of all Strowger switching equipment will have been eliminated from the Telex network.

Packet-Switched Network

The PSS, opened in 1981, is attracting many more customers than originally anticipated and, consequently, it is planned to increase the network capacity by 100% per year between 1981 and 1983; by that time there will be 25 exchanges in the network.

Earlier this year, customers to the international packet switched service (IPSS) were transferred to the PSS when the 2 networks were interconnected, access to the IPSS now being via the PSS. Interworking is to be provided between PSS and Telex customers. The Teletex service will be carried by PSS (as well as by the PSTN) and plans are in hand to connect Prestel computers to PSS to allow Prestel users to gain access through PSS to non-Prestel information providers.

Integrated Services Digital Network

The IDN will form a basis for the creation of a multi-purpose digital network—the ISDN. By means of digital access to the customers' premises, it will provide switched digital channels working at 64 kbit/s directly from one customer to another. Bulk access at 2 Mbit/s to customer PABX and local area networks (LANs) will provide efficient access to these switched channels for voice and data. This network will provide a comprehensive, economic and flexible range of voice, data (X-Stream services), and eventually visual telecommunications services.

The ISDN pilot scheme, which will serve some 250 customers by the end of 1983, is centred upon the System X large local exchange (LLE) in Baynard House in the City of London. Coverage will be extended beyond the normal exchange area by using remote digital multiplexors in London and Kilo-Stream transmission equipment for some out-of-London sites, for example BT's Research laboratories (BTRL) at Martlesham. Extension of the ISDN to Birmingham Midland LLE and Manchester Blackfriars LLE is planned for 1985 when main network digital access will become available between these centres.

Broadband Local Distribution Network

Analyses of technical options have demonstrated the possibility of a broadband local distribution network with most service demands for traditional telephony services, non-voice services and visual services being supportable by such a network.

BT intends to exploit its unique position (as an existing service provider) to play a major role as a carrier of video programme material to customers' premises (cable television). Studies continue into the best technical options for a broadband local network. BT already has experience of providing and operating cable television pilot networks, for example, at Milton Keynes.

Digital Private-Circuit Network

The rapidly growing penetration of digital transmission systems will be exploited to provide all-digital private-circuit services known as *KiloStream* and *MegaStream*. Some digital transmission capacity is being pre-provided and interconnected through special cross-connection sites at which provision and maintenance of private circuits can be effected, leading to a digital private circuit network (DPCN).

Cross-connection sites will be linked by 2 Mbit/s, 8 Mbit/s and 140 Mbit/s line plant as appropriate, and digital multiplexors will be provided at cross-connection sites to derive and interconnect digital channels. Initial implementation was embodied in phase 1 of a London Overlay Scheme in September 1981, which is being augmented and extended over digital trunk paths to other major city centres.

As part of the DPCN, a limited amount of specially developed transmission equipment will be installed on

selected routes between and in major cities to provide the KiloStream service, starting in 1982 and providing digital transmission paths between customers' equipment operating at 2·4, 4·8, 9·6 and 48 kbit/s; some 15 000 terminal ends are expected to be provided by the end of 1983. Cross connection at 64 kbit/s will occur at selected sites.

OPERATOR SERVICES

Forecasts indicate that the demand for the present telephone operator services for the inland network service will remain almost constant over the next 10 years and may then rapidly decline.

There is a need to provide a modern switching system for operator services that is compatible with System X; this will enable existing services to be maintained, according to demand, and new services to be developed.

NETWORK MANAGEMENT

Network management will be introduced to improve the reliability of service given to customers and to cope with traffic surges in the network resulting from its more sophisticated use. Special network management centres will undertake real-time surveillance of the network to detect failures and overloads. Traffic will be rerouted or blocked at the local exchange to minimise the effect of such problems.

THE FUTURE

Modern society's rapidly increasing need for a variety of sophisticated interactive telecommunications services is most effectively and economically met by an all-purpose integrated digital network of transmission systems, SPC circuit-switching and separate-channel signalling systems linking all local exchanges. This article has outlined the strategy for moving rapidly towards such an IDN and the continuing role for the specialised switched application networks. The whole range of network planning activities is driven by the high rate of technical change and the business environment; even as this overview is completed, further developments can be seen which complement existing plans.

ACKNOWLEDGEMENTS

The authors would like to recognise the wide ranging work carried out by many people in the preparation of this strategy, to place on record the assistance received in preparation of this article, and to thank Mr. R. E. G. Back for permission to publish it.

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British Telecom Press Notices

TRIAL BEGINS OF ADVANCED INTERNATIONAL TELEX FACILITIES

Nine thousand of British Telecom's London customers, mostly from the City, can now have access to new and improved international Telex facilities.

The facilities, called *Telex Plus*, include the ability to store messages and forward them at off-peak times when there is greater chance of successful delivery, to automatically re-try a number if initial attempts to get through are unsuccessful, to send the same message to up to 100 different addresses, and to hold files of addresses for regular multiple messages.

Telex Plus is a trial service, available at an extra fee to all customers who have Telex numbers beginning "88" and who wish to use the service. An enhanced service covering the whole of the UK and offering further facilities is planned for the spring of 1983. These services are now available through the technology of the new £8M computer-controlled Telex exchange in Keybridge House, London, which was handed over by the manufacturers to British Telecom International in February of this year.

ELECTRONIC TELEPHONE WITH BUILT-IN FEATURES

Britain's first electronic "featurephone", offering a wide range of special features at the touch of a button, is now available from British Telecom.

The telephone is called the *SL–1 Featurephone* and has been designed to exploit the facilities of the SL–1 digital electronic PABX, a large-sized proprietry PABX supplied by Reliance Systems Ltd. It offers a wide range of special features. In addition to the usual array of 12 pressbuttons for making calls, it has a row of 10 extra buttons that provide the user with access to the features of the PABX. These features include:

(*a*) automatic dialling (stored numbers can be called automatically by pressing a button);

(*b*) code calling (regularly-used numbers can be shortened to a code of one of 2 digits);

(*c*) charge account for cost call analysis;

(*d*) repeat calling of numbers called automatically but not answered at the first attempt;

(*e*) conference calls, interconnecting up to 6 extensions;

(*f*) call diversion, automatically switching incoming calls to an alternative extension if the first is not answered; and

(*g*) hold for enquiry and 3-party calls.

The 10 "feature" buttons can be programmed with any combination of PABX facilities, to suit the extension user's particular needs. Features are then accessed merely by pressing the particular button. The system confirms the feature operation by lighting the light-emitting diode (LED) associated with the button or by giving an audible response.

With an ordinary press-button telephone, (that is, one without the extra feature buttons) the user would access the PABX facilities by means of special codes that are particular combinations of number and control buttons. The SL–1 Featurephone puts these facilities at users' fingertips without their having to remember the access codes, or consult the directory for the code each time a facility is required. It also provides "on-hook" dialling, which leaves the user with both hands free to continue working until the call connects—indicated by a built-in loudspeaker. Further buttons provide control of this speaker volume, and enable calls to be held.

The SL–1 Featurephone is also available in a display version, with a 16-digit luminous display above the 12-button keypad. This display shows the number called, short-code numbers, the date and the time; it also gives the extension number of an internal caller.

The range of features available on a particular extension can be extended to a maximum of 60 by means of add-on modules, available in 10-button and 20-button sizes. A loudspeaker module is also provided for users who wish to hold conversations without using the telephone handset. Just over 100 SL–1 PABXs are on order or being installed, and this represents a total of nearly 50 000 extensions.

The Electronic Telephone

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UD 621.395.6

This article introduces the concept of the all-electronic telephone and serves as a foreword to a series of articles in this Journal on British Telecom's new ranges of basic telephones.

INTRODUCTION

It is often assumed that the rapid advances in electronics that have so radically altered the functions, size, and appearance of many consumer products should have engulfed telephone design a long time ago. The design of complex integrated circuitry has been in such a state of development for many years that it might be assumed that the apparently simple function of a basic telephone could well be performed by a fully electronic analogue of the instrument more effectively, more reliably and more cheaply. Until recently, however, such has not been the case. Some of the latest designs of British Telecom's (BT's) telephones—like the Ambassador telephone—employ electromechanical principles that were developed before the invention of the telephone itself. This is mainly because over the years the design of the basic telephone has been so refined and optimised that it has been difficult for new technology to compete. For example, the design of the 700-type telephone is such that the use of the individual components is maximised (for example, the bell resonating capacitor is also used for DC blocking, pulse shaping and spark quenching) and in such a way that the total number of components in the set has been minimised. Years of cost reduction and refinement of the component parts of the set have produced an instrument that is functional and cheap. To attempt to replace such an instrument with its fully electronic counterpart is a formidable task when the constraints of unit costs are considered.

Nevertheless, over the past decade or so there has been some slow ingress of solid-state devices into the telephone, but this has occurred in an evolutionary rather than a revolutionary way by replacing individual components or functional blocks within the telephone with electronic equivalents. A telephone can be considered to comprise 3 main functional areas: inward signalling, outward signalling, and transmission. Within these divisions, some of the functions are already being performed by electronic equivalents of the electromechanical piece parts; for example, the Tone Caller No. 8A in the Trimphone, the keysender in the Telephone No. 756, and the Microphone Inset No. 21A. This piecemeal approach of direct substitution of component parts by their electronic replacements has, to some extent, diverted the effort of designers from achieving a low-cost all-electronic telephone.

Over the more recent period, manpower rates have increased substantially and hence the cost of production, and maintenance, of conventional telephones, both of which are labour intensive, have risen. At the same time, there have been tremendous advances in the field of large-scale integration (LSI) so that the number of functions that can now be accommodated on integrated circuits is more than adequate for the requirements of signalling and transmission of a simple telephone. In fact, this spare capacity can be used to provide, at very little additional cost, extra facilities that could only have been achieved with conventional designs by the use of expensive, often cumbersome, add-on units. Furthermore, the trend towards press-button telephones (keyphones) adds to the attractiveness of electronics because this form of signalling is achievable economically only by these means, and with only a marginal increase in cost over that of the traditional dial.

ADVANTAGES OF FULLY ELECTRONIC TELEPHONES

The reader may now consider that the electronic basic telephone can offer no advantages over a conventional instrument—such is not the case. The most obvious (to the user) advantage is the provision of a keypad as standard. In addition, the user will enjoy the benefits of greater reliability and improved speech quality.

It is in this latter area of speech transmission that 2 new BT telephones have made their main contribution. These new telephones, the New Electronic Telephone (NET), now known as the *Viscount*, and the IneXpensive Telephone (IXT), now known as the *Statesman*, both offer speech transmission derived from an integrated circuit design supported by low-cost dynamic handset transducers. With this type of construction, the telephone is inherently free from the problems of high noise levels, distortion, etc. often associated with the carbon microphone/hybrid transformer design of transmission circuit.

To BT, the advantages of the introduction of electronic telephones are closely linked with the cost of labour. The effect of labour costs is significant in 2 main areas:

(*a*) in the maintenance of the instrument, and
(*b*) in the manufacture of the instrument.

At the present time, the cost of a maintenance visit to a customers' premises is comparable with the cost of the instrument that is being maintained. Obviously, any steps that are taken to increase the reliability of the instrument will show a substantial saving on the absolute cost of the instrument over its lifespan. Thus, in the design of the new electronic telephones, those components with a record for being fault prone are eliminated.

As stated earlier, increases in labour costs have meant that the traditional methods of telephone manufacture will not be competitive in the near future. A conventional telephone has several wound components (bell coils and hybrid transformers) and other mechanical components (bell and dial assemblies) that require human intervention in their construction. With the electronic telephone, this type of construction method is avoided and the labour element in telephone assembly is minimised. Where possible the new telephones make use of axial-lead components and dual-in-line integrated circuits and, in doing so, enable the component parts to be bandoleer fed to automatic component-insertion equipment. Where there is an unavoidable element of manual construction, the design of the piece part has been simplified. Thus, both new telephones employ an elastomeric type keypad—a rubber mat that greatly reduces the number of parts

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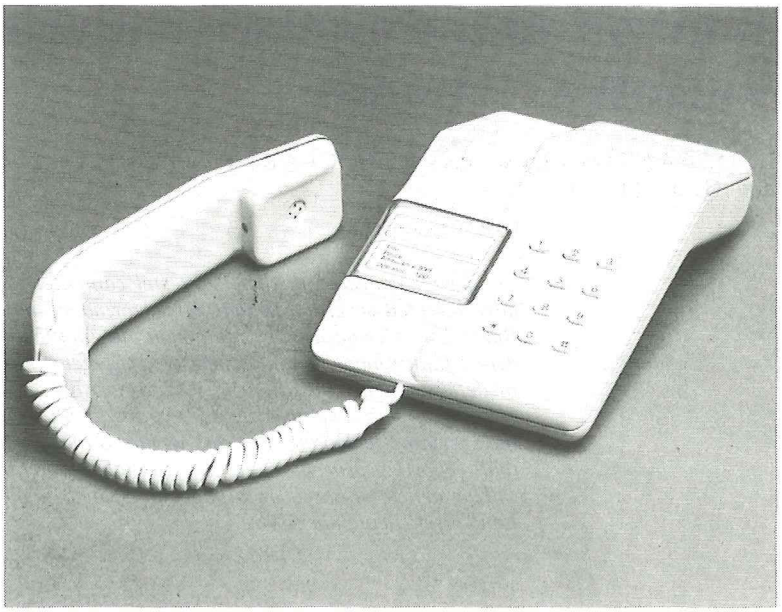
Viscount
(Telephone No. 9500)



Statesman
(Telephone No. 9000)

necessary for the keypad over conventional gold-plated spring-based techniques.

In general, the realisation of the telephone instrument functions by using integrated circuit requires less space than the conventional components; hence, the outward physical design of the instrument is no longer determined by the technology. The only constraints remaining are the man–machine interfaces.

FUTURE DEVELOPMENTS

There is one very important advantage of the electronic telephone that will have far reaching consequences for the future of telephone development. The electronic circuits that constitute the telephone do not require the same amount of power that a conventional telephone requires. Even on the longest line, the electronic telephone can operate with about one third of the power that is available. This liberates power which, on future designs, can be used to power semiconductor memories, displays and other circuitry. Hence, a basic telephone in the future will be able to offer multiple number storage and display of number, call progress monitoring and other more intelligent facilities when used in conjunction with low-power microprocessors or dedicated LSI devices.

CONCLUSION

It now seems inevitable that the electronic telephone will displace the electromechanical instrument over the next decade. However, this change should be accompanied by a change in the public attitude to the telephone. The design of the new telephones is no longer constrained by the components that the set must contain and, therefore, new designs need only reflect the ergonomic requirements of the instrument. Telephones will be selected to meet personal taste and home fashion, and, although the potential life of the new instrument may well exceed that expected for current instruments, it is likely that the dictates of fashion will ensure a rapid turnaround as new styles and facilities become available.

An article in this issue of the *Journal* describes the Viscount (Telephone No. 9500), one of BT's 2 new ranges of basic telephones. An article in the subsequent issue of the *Journal* will describe BT's other range of basic telephones, the Statesman (Telephone No. 9000).

Monitoring the Technical Performance of a National Videotex Network

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UDC 025.3: 681.31

The performance of the UK's Prestel computer network is of prime importance to British Telecom who have adopted several methods of performance monitoring to ensure a reliable service for its customers. Specialist microprocessor equipment automatically monitors the status of the computer input ports to detect faulty modems and computer equipment. Hardware monitors have been deployed at selected centres to determine the utilisation of various hardware and software processes. Mini-computers have been programmed to simulate user access to gain quantified information about response times. This article describes the specialist techniques that are deployed along with the more conventional computer and communications fault reporting procedures to give a reliable indication of the reliability and efficiency of the network.

This article is based on a paper presented at the International Computer Communications Conference, London, in September 1982.

INTRODUCTION

Prestel, the world's first public videotex†† service operated by British Telecom (BT), now has some 17 000 customers and is available to 62% of telephone subscribers in the UK on a local-call basis. To provide this service, customer access to an information retrieval computer (IRC) is given directly or indirectly via a remote multiplexer located in the customer's local service area. These IRCs receive their updated videotex page information from a central update centre (UDC), to which they are connected in a star configuration.

The monitoring of the performance of this nationwide and largely unattended computer network is of prime importance to BT and its customers in order that a reliable service may be guaranteed and that maximum use of expensive equipment may be made. To this end BT have adopted several methods of performance monitoring and these are described below.

VIEWDATA ACCESS MONITOR AND PRIORITY INCIDENT REPORT EQUIPMENT

Early in the operation of the original viewdata pilot trial computer at BT's Research Laboratories at Martlesham Heath, problems were experienced in maintaining a full service on the data modems used to access the computer ports —any faults which occurred were only discovered when complaints were received from users accessing the service. It was then necessary to make repeated test calls over the public switched telephone network (PSTN), busying out each line in turn until the fault was discovered. In addition, because of the possibility of faults in the computer software, it was necessary to cause the computer to transmit the initial page of data to confirm correct operation—this was usually done by humming at the correct frequency (390 Hz) into the handset and listening for the modulated data carrier from the computer.

When Prestel computers were planned (with 200 lines in unattended computer rooms), it was realised that it would be impossible to maintain an acceptable service unless an improved method for finding and clearing faults could be found. Proposals were therefore made for the provision of monitoring equipment to carry out the required functions.

Several standard data communications control systems were investigated to see if they were suitable for the application proposed. This study showed that they were primarily intended for use on high-value private-wire network circuits, such as those provided for banks and airline networks. These control systems provide sophisticated line-switching and fault-monitoring facilities, but require high-cost equipment at the operations centre, and on each line being monitored. They also require the use of the manufacturer's proprietary modems to minimise interface problems. It was thus decided to commence construction of a purpose-designed microprocessor-based system (using a Motorola M6800 microprocessor) known as *viewdata access monitor and priority incident reporting equipment* (VAMPIRE).

The VAMPIRE Hardware

Fig. 1 shows the mode of use of VAMPIRE, and its components are described below.

Monitor Interface

Four interface lines are monitored on each viewdata computer port. The signals monitored are

(*a*) calling indicator (No. 125‡),
(*b*) receive carrier detector (No. 109‡),
(*c*) transmitted data (No. 103‡), and
(*d*) modem telephone circuit busied (added control circuit).

The first 3 signals are derived directly from the normal computer/modem interface circuits at a point where they terminate on the back wiring. The last signal is derived from a contact of a relay in the modem control unit. Additional circuits enable the telephone line to be busied automatically when faults occur. Fig. 2 shows the arrangement.

Output from the VAMPIRE unit is transmitted to the remote operations centre at 1200 bit/s over a BT Datel 600 circuit with a full duplex return speed of 75 bit/s. The normal output generates a graphic-display table showing the status of the computer access ports using coloured squares to show the different conditions. Fig. 3 is a typical example. In

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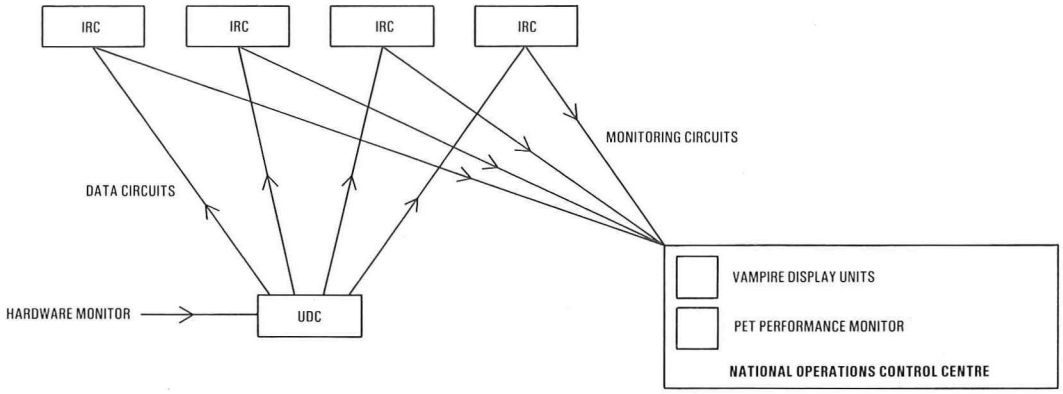
†† *Videotex* is the new International Telegraph and Telephone consultative Committee (CCITT) term for the system previously known as *Viewdata*

‡ These are the CCITT Recommendation V23 circuit numbers



IRC: Information retrieval computer
UDC: Update centre

FIG. 1—Network arrangements for performance monitoring equipments

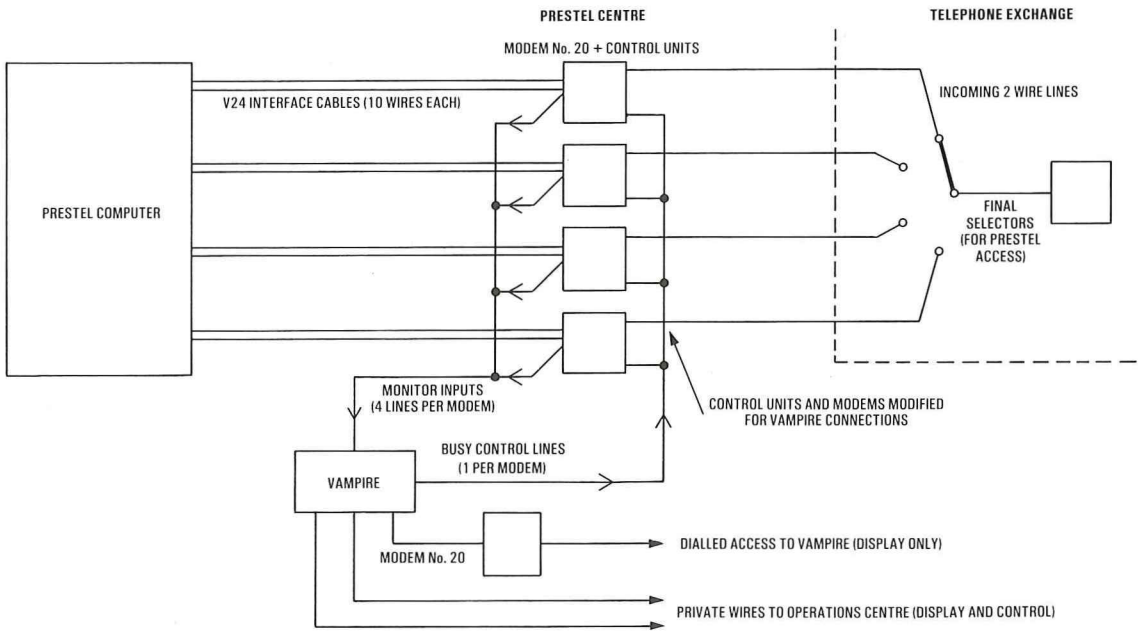


FIG. 2—VAMPIRE/Prestel interface arrangements

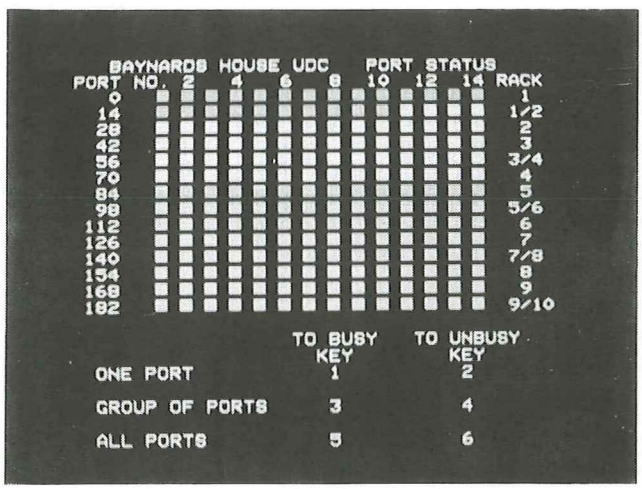


FIG. 3—Typical graphic display

addition, the control options available to the operator for busying lines are displayed as a viewdata menu choice. Pressing a numeric key for a valid choice causes the display to show a request to enter the port number(s) to be operated upon. Once a correct entry has been made, the action requested is executed and the normal port status display resumed.

Four separate output channels are provided to give access as follows:

(*a*) a private circuit to Prestel operations centre,
(*b*) a private circuit to the local Prestel manager's office, if required,
(*c*) an auto-answer switched telephone circuit for stand-by access in the event of a failure of the private circuit, and
(*d*) a direct circuit without a modem for local test purposes.

The main hardware for the VAMPIRE equipment is based on a card frame, using 3 shelves. The top shelf contains the microprocessor, random-access memory (RAM), read-only memory (ROM), serial input/output cards, and the power supply. The second and third shelves contain parallel input/output cards, which are used for interfacing to the modem

equipment being monitored. All the cards are connected by a common microprocessor bus extension backplane which is terminated to the component side of the printed wiring cards. The non-component side of the parallel input/output cards are brought out to rear panel connectors for linking to the modem racks, using 4 circuits for input monitoring and one circuit as an output to drive a *busy* control circuit.

The VAMPIRE Software

The programs for the VAMPIRE unit are held in non-volatile memory so that either power on restart, or manual reset will initiate full operation of the unit.

Start-up Routine

On initial start-up, all *busy* control outputs are set to the OFF (unbusy) state. Each port on the monitor interface is then scanned in turn and any port which shows a BUSY state is recorded in the status table as not in use; during normal status scanning these ports are skipped. This enables ports to be busied locally for maintenance purposes. When a port is restored to service, the engineer on site presses the RESET switch to cause VAMPIRE to make a new start-up scan.

Status Monitor

The monitor ports are scanned in sequence at least once per second and the status of each port recorded in the status table. The TRANSMITTED DATA status is latched when a logic 0 is detected at the commencement of transmission. This status is held until the *modem-on-line* signal goes to logic 0 at the end of a call.

The *calling-indicator port status* signal has a software delay to prevent the intermittent ringing signal giving a false display indication.

All other status bits follow the transitions of their related input signal.

Display Driver

A graphic display of the complete 196 ports is generated and transmitted to all 4 display outputs at a speed of 120 characters/s. The display is updated continuously during normal status display, with a cursor *home* character (from the ISO† 646 standard set) after each 960-character frame block.

Each port status rectangle in the display is set to the colour appropriate to the current state of the port. The colours used are the standard videotex colours as described in CEPT* Recommendation No. T/CD6–1.

The display terminal used to receive the output from the display interfaces is a standard viewdata receiver as defined in the UK Prestel Service Terminal specification[2] which also gives full details of the transmission standards used on the display interfaces.

Error Reporter

An independent, real-time process checks the status table entry for each port and if an error-state is detected, the busy control output for that port is set to ON. An error-report message is then transmitted to all the display outputs, together with printer control characters to enable a printed record to be made at those control centres equipped with printers. This error-message is formatted such that the busy choice display is completely overwritten and the status display is left intact for the period of the error display (see below). ISO 646 characters *DC1* (print on) and *DC3* (print off) are used for printer control.

The error-display is maintained for 1 minute before normal status display is resumed. The error-states that are detected are:

(*a*) modem on line for 20 s with no *received carrier* signal, and

(*b*) *received carrier* signal true and no TRANSMITTED DATA transition within 2 s.

Busy Control

Receipt of a *busy choice* character on any input causes all other inputs to be inhibited for 20 s. This time-out is renewed on each subsequent character received from the active input. The received character is tested for validity as a *busy choice*. Receipt of a valid character will cause a reply message to be sent to all active outputs, using one of 6 display frames selected by the value of the received character. This reply overwrites the busy choice display, leaving the status display intact for operator convenience. The status display will not be updated during the busy control time-out period.

After a valid *busy choice* character, a 3-digit character string is received from the active input and formed into a port number or code number. This number is checked for validity in relation to the chosen busy command, and an error-message sent if the number is incorrect. If the *busy choice* requires a second number for the operation chosen, the above operation is repeated. In addition, the 2 numbers are checked to ensure that the second entry is equal to or greater than the first before proceeding. After all the required input has been received, the busying operation is carried out and the normal display of status resumed.

Operator's Console

The display output from VAMPIRE is transmitted over a private circuit to the Prestel control centre. At the control centre, a standard Prestel receiver is used to display the status information. The use of colour has been found to be essential in giving a clear indication of the status of the monitored ports.

THE PET PERFORMANCE MONITOR

Early in the public use of the Prestel system, it became apparent that the human estimation of the system response time was highly subjective. Widely varying reports on the acceptability of the speed of the system were received, many of them relating to coincident periods. Additionally, manual attempts at measurement of response time were of limited success primarily due to the short intervals to be measured, the ergonomics of the timing process and the tedium factor.

The need for an autonomous mechanism for the measurement of the performance of the system was thus demonstrated. This mechanism would be required to provide accurate timings of system responses (in an easily digestable format) and should be capable of running unattended for extended periods. It should also relate its findings, at regular intervals, to the overall load on the system.

Hardware

Initial research into the provision of a performance monitor was based on a Commodore PET microcomputer and the current implementation remains on this device as its 8 Kbyte memory is just sufficient. The program is written in BASIC for ease of maintenance. The PET is interfaced to Prestel via a bidirectional RS232 interface and a standard modem. A spur is taken from the receive side of the modem and used to drive a Prestel terminal as a slave. This permits visual confirmation of

† ISO—International Organization for Standardization

* CEPT—Conference of European Postal and Telecommunications Administrations

the activity of the PET. An interface is also provided to a 30 characters/s printer.

Control Data

The PET Process is driven by a data stream that contains control information, which determines the sequence of activities, and data that is sent to Prestel. The latter is timed.

The data that is transmitted to Prestel is logically divided into 2 basic categories: user facilities (frame retrieval etc); and Information Provider (IP) facilities (frame editing). This latter category is further subdivided into *edit control* (the IP dialogue which establishes a frame's characteristics; that is, number, price etc), *frame construct* (in which the visible part of each frame is established) and *edit ends* (which signify the completion of edit of frames and trigger their inclusion into the database). These 4 categories are deemed to have potentially differing criteria of acceptability of response and their independent monitoring permits separate results to be produced for each of them.

Time Bands

The interval between the transmission of a character to Prestel and the receipt of the first (or only) character of response is measured by the PET's internal clock. According to the value of each measured interval, one of 5 time-band counts allocated to each data subdivision is incremented by one. The process thus maintains counts of the number of characters within each category whose response times fall within certain prescribed limits.

The predefined time bands, each of which is exclusive of any which precedes it, are: up to 0·5 s; up to 2 s; up to 5 s; up to 10 s; and over 10 s. Of these, the first 2 encompass most of the results on live systems, the last 3 being intended for exception reporting and loading trials.

Because of the coarse nature of the time bands, a separate reporting level may also be specified for each category of data. Any character whose response time exceeds this level is subject to an explicit report which specifies the exact response interval and the time at which the delay occurred.

System Load

The system manager function of Prestel owns a page on which certain load characteristics of the system are constantly updated. The monitor is granted access to this page and periodically reads it to extract information relating to the current occupancies of the machine ports and the user and editing systems.

Results

Every thirty minutes, on the hour and half hour, the monitor outputs a cumulative table of results to the character printer. This table is prefixed with the time of day and the last set of load characteristics extracted from the system. The table's columns represent the time bands and a linear total of characters in each row. There are 5 rows of information; one for each of the 4 data categories and a totals row for the overall system. Each entry in the table thus indicates the number of characters within the appropriate category (or overall) whose response times fall within the indicated time band. Appended to each count entry is a percentage indicating the proportion of the total responses for the category that are contained in the time band (see Fig. 4).

The results given in Fig. 4 are taken from the live system and show that all responses from Prestel over the monitored period were received within 2 s and that 94% were within 0·5 s. All but 2 of the user system and frame construct inputs (which are of a particularly sensitive nature) were replied to within 0·5 s, this boundary being that which is subjectively satisfying for these categories. Larger proportions of edit controls and edit

```
TIME IS 103004 ON TUE 22SEP 1981
RESULTS SINCE 084543
102803 S/PARMS: 50 PORTS, 0 USERS & 34 T/PS
TIME VALUE (SECS)    <0.5    >0.5-2    >2-5    >5-10    >10    TOTAL
0-USER SYSTEM
              NO:     217         2       0        0      0      219
              %:       99         1       0        0      0
1-EDIT CONTROL
              NO:     385        15       0        0      0      400
              %:       96         4       0        0      0
2-FRAME CONSTRUCT
              NO:     174         0       0        0      0      174
              %:      100         0       0        0      0
3-EDIT ENDS
              NO:       4        31       0        0      0       35
              %:       11        89       0        0      0
TOTALS
              NO:     780        48       0        0      0      828
              %:       94         6       0        0      0
```

FIG. 4—Typical table of results from the performance monitor

ends exceeded 0·5 s, but these areas are less demanding in their acceptability of response.

For the convenience of interested parties who are not collocated with the monitor, the current table of results may also be written to a frame on the Prestel system.

The tabular format of the monitor's reports, together with the allocation of response times to bands, leads to very rapid visual assimilation of each set of results; thus little time is wasted in interpretation when the system is behaving in a satisfactory manner. However, if things go awry, the presence of the exception reports (printed above the half-hour period to which they refer) enables rapid identification of the rogue category to be made.

Scope

Prestel's National Operations Centre maintains a constant monitor of the performance of the UDC (where all editing is carried out) during normal office hours; this is the period when any loading problems can be expected.

All output is sent, on a daily basis, to the team responsible for system performance and is used, in conjunction with that from the hardware monitor (described below), to enable tuning adjustments to be made to the configuration of the system if increased load during the life of a system version so demands.

Alternatively, the PET system may be used to monitor the performance of the IRC machines.

Additionally, the development team maintains a further PET system which is used, *inter alia*, for performance measurement of new system versions as they are produced. Before such a system is released for live use, it is subjected to a flood test during which it is made to experience load levels considerably higher than those it is expected to meet in the public service. This machine also provides back-up for the operational systems.

HARDWARE MONITORING

A hardware performance monitor is used at the UDC to record the average central processor unit (CPU) and selected disc drive usage, as a percentage, during each 15 minute period. These records are further averaged to half-hour periods to match the PET figures described above. The monitor also carries out a sample, every millisecond, of the current program in use and it is from this data that the heaviest CPU usage programs are determined.

The output for a typical month is given in Tables 1–3 (the figures included in the tables are illustrative only).

In addition to the usage times shown in the tables, the CPU idle time (typically 37·94%) and the overlay activity; that is, the average number of accesses to the overlay area of the

TABLE 1
Highest Recorded Usage During Month

		Half-hour period commencing	Date
Port usage	70%	9.30	1 Oct 80
IP usage	49%	9.00	29 Oct 80
CPU usage	66·05%	11.00	28 Oct 80
Disc usage	22·04%	11.30	27 Oct 80

Note: These are the highest recorded usage figures and occurred during the half-hour period on the date shown

TABLE 2
Top 5 Periods for Port/IP Usage

Ports				IPs			
Number	Half-hour period commencing	CPU Percentage	Disc Percentage	Number	Half-hour period commencing	CPU Percentage	Disc Percentage
45	15.30	66·74	13·34	39	11.00	72·67	14·14
45	10.30	74·92	15·33	34	15.30	66·74	13·34
43	11.30	72·35	16·83	33	11.30	72·35	16·83
43	16.00	62·38	15·89	33	14.30	61·29	13·69
43	15.00	66·61	17·03	33	16.00	62·38	15·89

Note: This shows the periods during which the Port/IP usage was highest (averaged over the month), together with the corresponding average CPU and system disc usage

system disc per minute, (typically 476) are also monitored and reported as averages over the month.

Although it is not expected that the detail given above will be understandable by readers not familiar with the Prestel system and its program names, it does illustrate the degree of detail that is necessary for performance optimisation and available to Prestel system designers.

CONCLUSIONS

The response to VAMPIRE, by the Prestel operational staff, was favourable. Even with a very simple display they have found the equipment useful in detecting Prestel failure before any other indications of error are apparent. The use of colour has proved to be a very convenient method of highlighting various status conditions. Although VAMPIRE was developed specifically for Prestel, it is possible that similar equipment could be used by other operators of large computer bureaux using the PSTN.

The output from both the PET and the hardware monitor have proved essential in both monitoring and optimising the performance of the Prestel national network. The operators of national videotex systems go through 3 phases. The first is the easiest; it is an acquaintance with display technologies. The second is familiarity with stand-alone computing systems. The last is an appreciation of the true problems of running a national network, and it is this area that the techniques described above are highly relevant.

TABLE 3
Top 10 Programs for CPU Usage

Program	Percentage Time
TSC	14·56
TIM	12·22
ORG	8·81
TK4	4·43
DDS	3·55
BASO	3·46
OPTM	2·51
TFO	2·54
GATE	2·10
PC	1·95

Note: These results are given as a percentage of the non-idle time and averaged over the month.

ACKNOWLEDGEMENTS

Acknowledgement is made to the Director of Research of British Telecom and the Director of Prestel for permission to make use of the information in this paper.

References

[1] CEPT Recommendation No. T/CD6–1. European Interactive Videotex Service. Display Aspects and Transmission Coding.

[2] Prestel Terminal Specification. Edition One. Prestel Liaison Group Technical Subcommittee, Telephone House, Temple Avenue, London EC4Y 0HL.

British Telecom Press Notice

MORE ELECTRONIC PRESS-BUTTON PAYPHONES ON THE WAY

An order worth more than £40M for 65 000 new electronic press-button payphones has been placed by British Telecom (BT). The new payphones will start to be delivered early in 1983, and will mark the next stage in the replacement of existing pay-on-answer payphones inside public kiosks. All 77 000 public payphones will be replaced by the mid-1980s. Earlier versions of BT's electronic payphones are already installed in about 2000 locations where payphones are heavily used, such as railway stations, throughout the country.

The new payphone is microprocessor controlled and automatically alerts engineers of faults, and when the coinbox needs emptying. The payphone has a single slot and takes a selection of coins: 2p, 5p, 10p, 50p, and the new 20p and £1 coins. It can be used to make direct calls abroad.

Money is inserted before a call is made, and the amount is stored as a credit and displayed. As the call progresses, the amount displayed diminishes; an audible and visual warning is given shortly before the money runs out. Users can insert more money at any time during the call. At the end of a call, the payphone will refund any wholly unused coins, or the credit can be used to make further calls by pressing a FOLLOW-ON button.

The 65 000 new payphones will be manufactured by Plessey Telecommunications Ltd. in its northern factories; 55 000 of these will replace the present public pay-on-answer payphones and 10 000 will be used as renters' payphones for hotels, public houses, etc.

The Edgeley Electronic Queueing Equipment

D. R. DONNELLY, and R. J. HIRST†

UDC 621.395.345: 621.395.66

The heavy use and high maintenance costs of running the existing Strowger directory enquiry call queueing systems in Manchester South Area led to a more modern approach being considered. A feasibility study showed that a microprocessor-controlled system was viable and could be produced locally. A team of 6 maintenance engineers designed, built and installed the Edgeley Electronic Queueing Equipment in 18 months. An outline of the system is given in this article.

INTRODUCTION

The Edgeley Electronic Queueing Equipment (EEQE) is microprocessor controlled and provides automatic queueing of calls, dealt with on a first-come, first-served basis. Using a single queue, with 48 incoming circuit terminations, the system has capacity for 32 operator positions, including 4 monitorial positions and 4 outgoing transfer circuits. The processor provides automatic queue control; it decides how many calls should be placed in the queue according to the number of positions staffed, queues calls at the rate of 1·3 (adjustable) to every operator, and gives engaged tone to the remaining customers.

Various technologies and configurations were proposed, but TXE4 junction A switches were finally chosen. A single full-availability matrix arrangement was selected. Multi-stage switches were rejected for this size matrix following a mathematical analysis, and on the grounds of wiring complexity. As the new system has been designed to make a second routeing attempt to another operator in the event of first-attempt failure, the second-try feature of multi-stage switches is not needed.

Full control of the system is exercised by a single 8085 microprocessor, combining a degree of system intelligence with low cost, flexibility and simplicity. This one microprocessor knows the states of all parts of the system, identifies faults and holds a large reserve of statistical information.

The man–machine interface used for both maintenance and statistics is an inexpensive Commodore Personal Computer (PET) with visual display unit (VDU) and printer. Software, written in BASIC, is available on site in the form of pre-recorded cassettes. All information is displayed on the PET VDU, and hard copy can be presented in various formats, including bar charts, via the printer. It is possible to replace the PET with a more sophisticated model, capable of additional functions.

The system incorporates many improved features, and flexibility is the keynote of the design. The line circuits and operators' console units are plug-in devices, which can be changed easily and quickly. On the directory enquiry supervisor's desk console unit, 7-segment liquid crystal displays (LCDs) indicate queue length and either busy tones or positions staffed. This console also gives audible and visible alarms if the number of busy tones exceed a preset value, giving the supervisor the opportunity to increase staffing levels. Training supervisors can monitor calls without adversely affecting the transmission. The operator's console incorporates a light-emitting diode (LED) display to indicate incoming calls; this replaces ringing tone, which caused annoyance in earlier equipment. On the completion of a call, there is a minimum 2 s period before the presentation of a further call.

FIG. 1—Typical office-type DQ bureau with the EEQE system and microfiche directory records

After an initial trial period, the new system was put into full use in June 1981 (see Fig. 1). It has fulfilled the expectations of the engineers, and gained the approval of exchange staff and the public who have commented favourably on the engaged-tone response; previously, customers had complained when a long wait with ringing tone had led them to believe the line was unmanned. Maintenance, which is minimal, can be carried out quickly and easily by British Telecom (BT) staff who have basic electronics experience.

Compared with the Strowger/Southampton system, the EEQE uses floor space very economically. The shoulder-high cabinet requires only about half a square metre of floor space This can be in office-type accommodation; no equipment rack space is required. (See Fig. 2).

FACILITY SCHEDULE

A schedule of the facilities offered by the EEQE is given below.

(*a*) Calls are queued in a first-come, first-served order, with the exception of the arrangements described in (*f*) below.

(*b*) Automatic queue shortening allows the processor to make its own decisions as to how many calls should be placed in the queue or given busy tone, in accordance with the number of staffed positions—a position is opened by the insertion of an operator's headset plug. The number of calls permitted into the system is 1·3 times the number of staffed positions.

(*c*) Queue length and either busy tones or positions staffed

† Manchester South Telephone Area

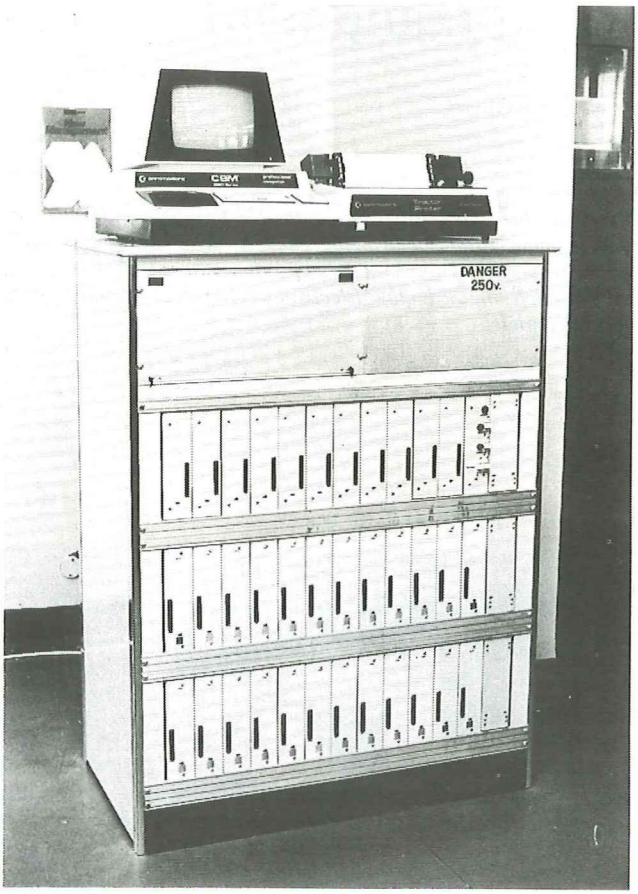


FIG. 2—Edgeley electronic queueing equipment

can be displayed on 7-segment LCDs, on the directory enquiry supervisor's desk console. On this console, an audible and visual alarm is given if the number of busy tones exceeds a preset value.

(*d*) The system is self-contained, in that it provides all its own incoming relay-sets, outgoing relay-sets, call switching and monitoring equipment. Only office-type desks need be supplied.

(*e*) The operating procedure is similar to that of existing systems.

(*f*) Three incoming lines (lines 46 to 48) from the A board have priority over normal traffic, but have access only to monitorial positions.

(*g*) Transfer facilities are provided as follows:

(*i*) Ordinary positions
1—to the supervisor, and
2–4—to monitorial positions.

Any of the 3 monitorial transfer circuits can access any of the 4 monitorial positions; that is, the first available position is selected.

(*ii*) Monitorial positions
1–3—to outgoing junctions,
4—to supervisor.

Monitorial positions are provided with a keysender.

(*h*) Calls are distributed in rotation to the available operators' positions.

(*i*) Calls that have been transferred are completely removed from the transferring operator's position; the transferring operator is available for further traffic after a 2 s delay on the same incoming circuit. This facility enables the provision of only one incoming circuit per operator.

(*j*) The system caters for up to
32 operators, including 4 monitorial positions,
48 incoming junctions, including 3 from the A board,
3 outgoing junctions, and
1 supervisor's transfer circuit, which appears on all the supervisors' standard key-and-lamp units.

(*k*) Man–machine interface is via the PET for statistics gathering and maintenance purposes.

(*l*) A printer is provided for hard copy of the results of the facility described in (*k*).

(*m*) Under catastrophic failure conditions of the common control equipment, direct connection of incoming junctions to operators' positions can be made by manual operation of keys.

(*n*) At night, if no directory enquiry position is staffed, it is possible to arrange for 2 positions to display their incoming calls to the enquiry board where they can be answered. (See also the facility described in (*q*)).

(*o*) Adjacent to the operator's telephone jack there is a second jack to enable the supervisor to overplug and gain access to a call, without degradation of transmission.

(*p*) The training supervisor has access to monitor any operator for training purposes; there is no transmission facility.

(*q*) Any call can be forced released from the system as far back as the line circuit by the operation of the FR key on the operator's console.

On night service, the night staff can force release a call by using the FR key on the console of the circuit concerned. This key is not brought out to the enquiry board.

DESCRIPTION OF THE PROGRESS OF A CALL

At any time, the processor will have decided whether further calls can be dealt with and set the line circuit memory accordingly. An incoming call (loop on the junction) operates relay L (see Figs. 3 and 4). Contact L1 provides a fast guard earth on the P-wire if required. The customer receives either busy tone or ring tone, according to the state of the previously set memory element. If busy tone is sent, no further processing of the call takes place (except that it is logged as a busy tone connected call). If, however, ring tone is connected, contact L1 calls the processor, and the processor allocates a queue number to this call.

The processor continuously routes the calls that have the lowest queue number, as and when operators become available. Having decided which cross-point to operate, the processor marks the relevant X and Y co-ordinates of the reed matrix. A voltage of −26 V is applied to the line circuit M-lead, and −50 V is applied to the operator's circuit H-lead; this results in only one reed relay (CP) being energised, since only one diode (D1) is forward biased. Contact CP1 removes dependency on the −26 V mark Y supply by reverse biasing diode D1. Contacts CP2, CP3 and CP4 connect the P, negative and positive wires through from the line circuit to the operator's circuit. The continuity-detection circuit checks the applied conditions, signals correct connection back to the processor and lights the CALL LED on the operator's console (see Fig. 5). Cross-point marking can then be removed. Relay CP is held from the earth at contact L2 to the −26 V on the H-lead.

The call is answered by the operation of the ANSWER key (ANS). Contact ANS1 puts an earth on the P-wire, which inhibits (trips) ring tone. Contacts ANS2 and ANS3 connect the speech path. The operator's telephone circuit has a local battery and earth supply; this, in conjunction with capacitors C1 and C2 and relay L in the line circuit, provides a single transmission bridge.

There are 2 headset jacks: one to open the position, and one for supervisor intervention. The receivers are connected in parallel and the transmitters in series by using a special break contact on the second jack. No degradation of trans-

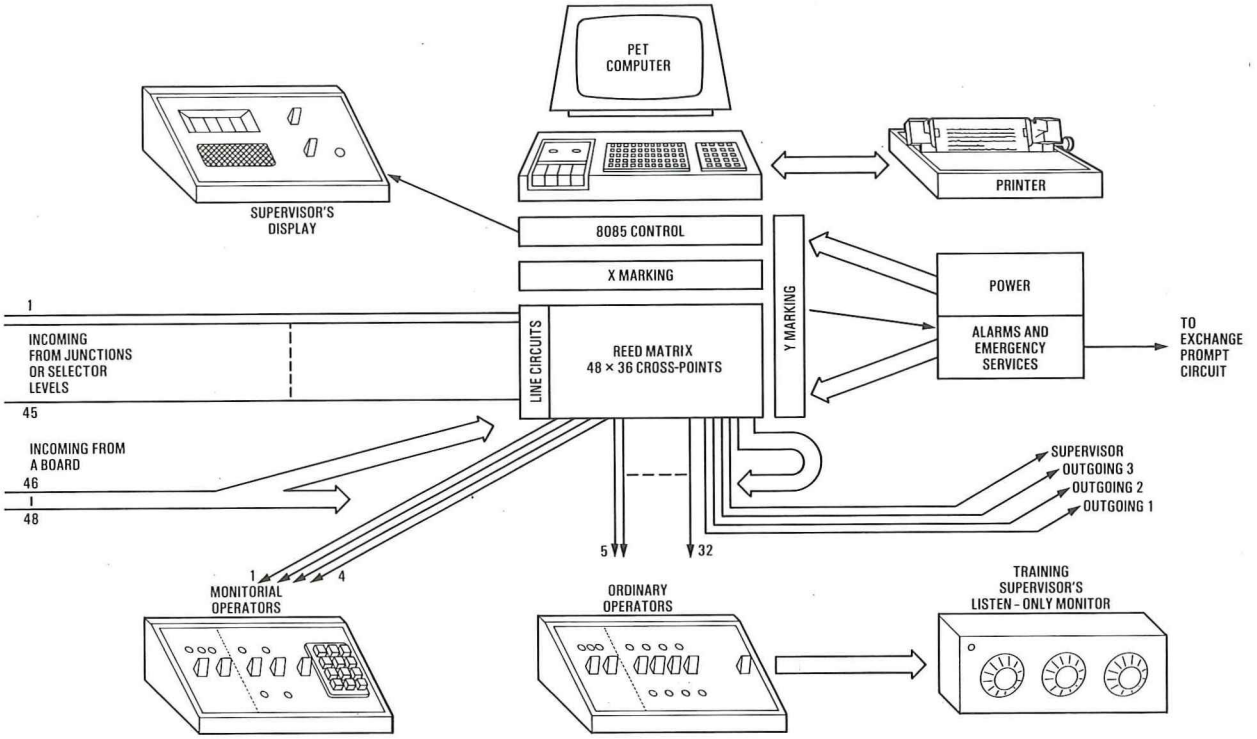


FIG. 3—Block diagram of EEQE

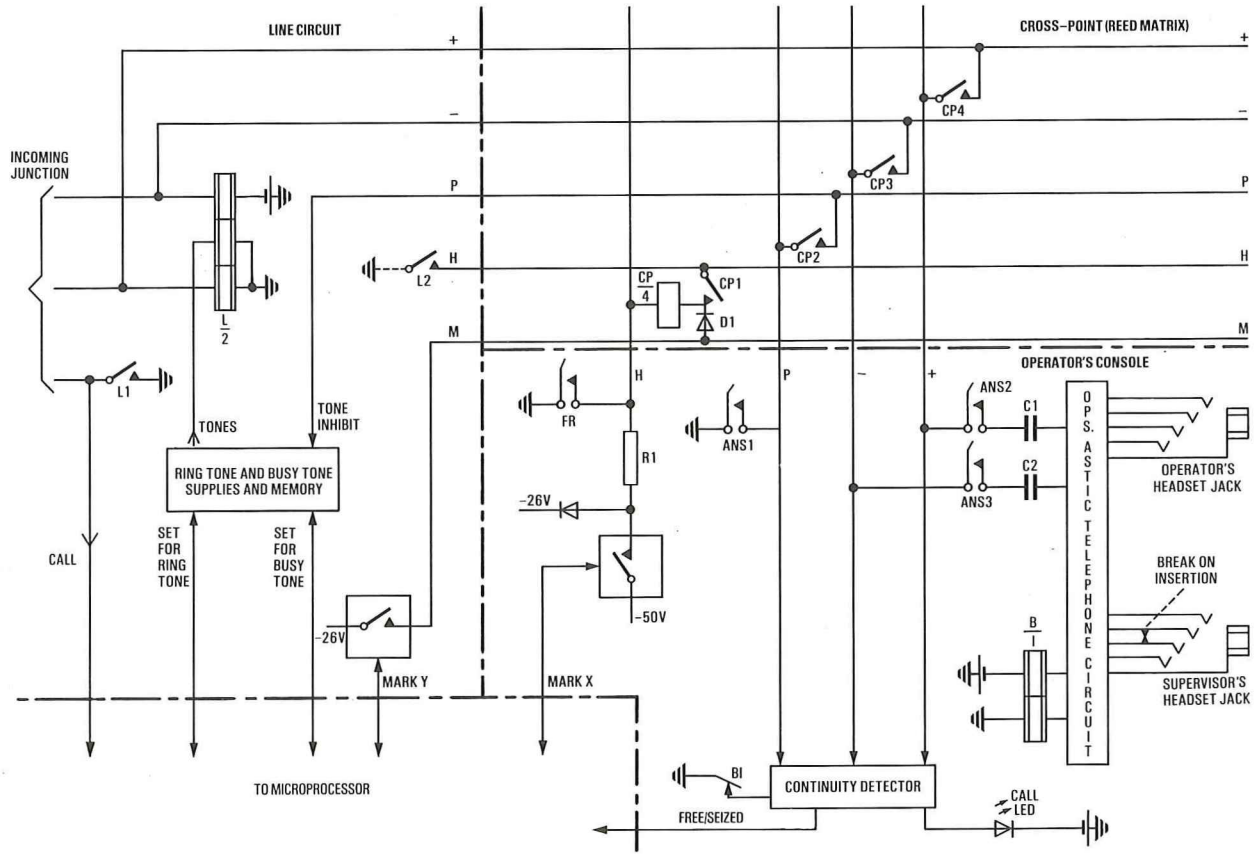


FIG. 4—Circuit diagram of EEQE

mission occurs when the supervisor's jack is used, because the telephone circuit regulator compensates for the additional resistance of the second transmitter.

The customer controls the call so that cleardown normally occurs when the loop is removed from the incoming junction by the customer. This causes relay L to release; contact L1 removes the call condition from the processor, contact L2 disconnects the hold path for relay CP, thus releasing the operator. If a customer fails to clear down, the operation of the FORCED RELEASE key short circuits relay CP. The operator is available for further calls, and the line circuit remains held with no tone and does not generate another call.

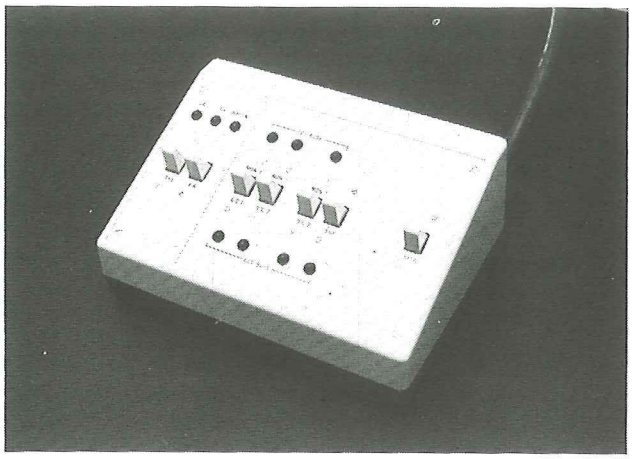


FIG. 5—Operator's console

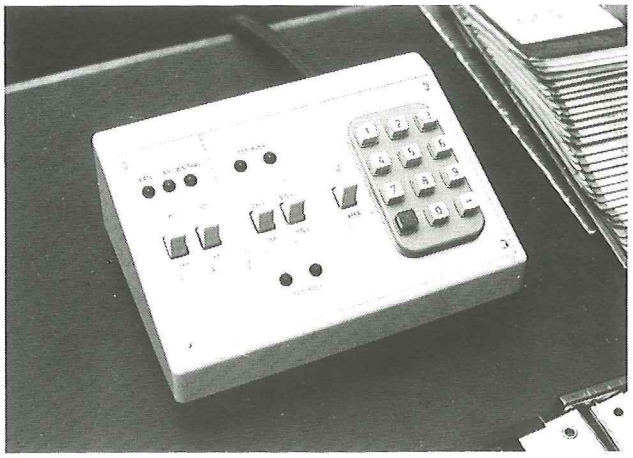


FIG. 6—Monitorial position console

CALL TRANSFER

Calls can be transferred to the monitorial position (see Fig. 6) or the supervisor. Prior to transfer, the transferring operator speaks to the transfer destination over an intercommunication link, with or without secrecy from the caller. This informs the transfer destination about the call to be transferred. Transfer is effected by setting up a program, which force releases the original cross-point and operates the cross-point specifically requested by the transferring operator. This completely removes the call from the original operator who is left free to accept further traffic.

SUPERVISOR'S DISPLAY

The processor collates simple information about the current queue length, the number of busy tones supplied per minute and the number of opened positions. This data is converted into binary-coded decimal and time multiplexed on a single −50 V, 5 pulses/s signal wire. A display circuit (see Fig. 7), provided for the directory enquiry supervisor, contains a shift register which is continually updated by the incoming data stream. During a frame synchronisation period, the contents of the shift register are latched into an LCD driver chip. A flag bit, inserted into the data, is used to activate an alarm light and buzzer, to indicate that the number of busy tones has exceeded a preset value (currently, 5 in 1 min).

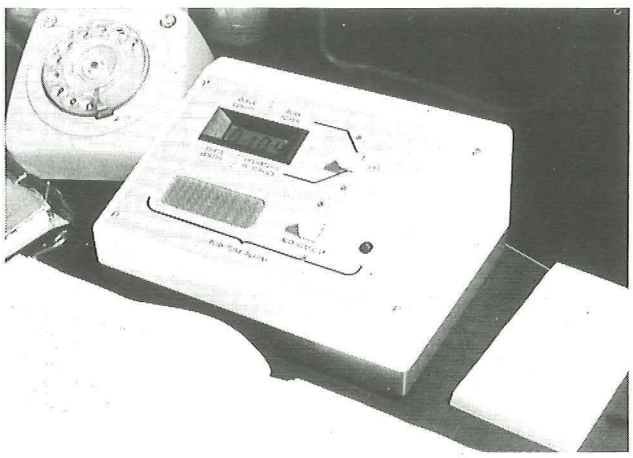


FIG. 7—Supervisor's display unit

TRAINING SUPERVISOR'S MONITOR

A high-impedence unity-gain amplifier can be connected to any operator's position by means of a set of rotary switches. This enables the training supervisor to monitor calls, without interfering with transmission.

THE PET COMPUTER

The 8085 system processor creates a database containing information about the state of all parts of the system. A means of gaining access to this information, with a minimum of design effort and without overloading the system processor, has been evolved, using an off-the-shelf PET computer for instructing the system processor to execute simple data collection subroutines. The PET computer has 8 Kbytes of random-access memory available to the user, a calculator-style keyboard and an integral cassette deck. Any personal computer, with an 8 bit port, could have been used.

Communication between the PET computer and the system processors is via a special interface, consisting of a small (1 Kbyte by 1 bit) mutually-accessible memory and a set of optically isolating buffers. The memory enables conversions of baud rate between the 2 processors, and optical isolation ensures the system cannot be damaged by the power-supply arrangements of the PET computer.

The PET computer makes the necessary conversions from machine level to decimal and English. The graphics and scientific functions of the PET computer provide enhanced presentation of the information. Programs for the PET computer are written in BASIC and a large repertoire of programs is kept on audio cassettes.

THE PRINTER

A Commodore 3022 series tractor printer has been used which is compatible with the PET computer using the IEE 488 bus. It is a dot matrix printer, which can reproduce all the graphics for the PET computer and has sufficient intelligence to format floating point numbers into columns.

THE SOFTWARE

There are 2 sets of software to be considered: system software written in 8085 machine code, and PET computer software written in BASIC.

System Software

The system software divides essentially into 2 categories: time-shared and non-time-shared. The time-shared programs are responsible for all supervision; that is, counting, timing

and logging. They are executed every 100 ms, initiated by a hardware interrupt signal. They are designed such that every line and every operator appears to have a supervisory program of its own. The non-time-shared programs calculate the optimum queue length, perform any necessary cross connections, and carry out any communication with the PET computer if required. This is repeated continuously until the 100 ms interrupt occurs and the time-shared programs are run. After time-shared program execution, the non-time-shared program is resumed at the point where the interrupt occurred.

Time-Shared Programs

The first program increments the system calendar clock. Thus, when any data is accessed by the PET computer, the time can be quoted, ensuring confidence that records are correct. The database holds totalled statistics for each separate shift, for a full previous week. At the end of a shift, the contents of the penultimate shift memory are moved into the ultimate shift memory, and so on through all shift memories. Eventually, the statistics for the current shift are moved into the previous shift memory, and the current memory is set up to zero.

The next program is responsible for call supervision and increments the set of current shift memories for each of the following: connections to busy tone, calls answered before or after 25 s, calls abandoned, and each second of equipment, or operator, occupancy.

The line-cord-circuit program supervises the state of each line. When given an outlet number by a call-switching non-time-shared program, it also supervises associated operators. The line-cord-circuit program operates on a set of registers allocated to each line. The following list indicates the type of information stored:

(*a*) The state of call—idle, applying tone, connected to an operator, operator answer etc.

(*b*) Queue number—the number of calls to be cross connected prior to the present call, plus one.

(*c*) Time out—the length of time since the application of the calling loop, up to 255 s.

(*d*) Outlet number—the address of the operator's state-of-call register with which this program is to be associated.

Each operator also has a state-of-call register, which is accessed by both the line-cord-circuit program and an operator management program. The line-cord-circuit program is responsible for changing the operator state of call to CALLING, then to ANSWERED and, finally, placing the register in a CALL-CLEARDOWN mode. The operator management program picks up the cleardown request and, after a 2 s count-down, causes the operator state to become IDLE. Another function of the operator management program makes the operator state-of-call NOT STAFFED when the headset is removed from the position circuit.

The next program informs the operator of the receipt of the request for forced release or transfer of a call, by lighting the computer ACKNOWLEDGE lamp for a brief period. Any transfer requests are then logged, together with the required destination, to be dealt with later by a non-time-shared program. The supervisor's display is updated, and then program execution returns to the point at which the non-time-shared programs were interrupted.

Non-Time-Shared Programs

Once the computer ports have been initialised, and the states of any calls existing prior to computer start or re-start have been determined, the following programs are executed in sequence.

The first program determines the desired queue length and sets the busy-tone/ring-tone memory element in the line circuits accordingly.

The next program cross connects calls. This is done by looking for the coincidence of 2 events:

(*a*) an operator being available—if more than one is free, the next in rotation is selected;

(*b*) a line that is calling—if more than one is calling, the line with the lowest queue number is connected.

The appropriate marking conditions are sent out to the reed matrix and confirmation of the continuity of the cross connection is ascertained. If continuity is not established, a second attempt is made, to a different operator, at the next opportunity.

Any transfer requests that have been logged are cross connected. This is accomplished by a programmed forced release of the original cross-point, and the operation of the cross-point requested by the transferring operator.

If the number of calls that have been given ring tone, but have not yet been cross connected, exceeds one, the CALLS WAITING lamp on every operator's console is lit. The information to be sent to the supervisor's display is gathered from the database and passed to the time-shared program for transmission. The states of all parts of the system are examined for fault conditions, and an exchange prompt alarm is generated if required.

The queue numbers allocated to incoming calls are in the range from 1 to 255. To prevent calls being dealt with in the wrong order when queue numbers 255 and 1 have been reached, a program extracts all the queue numbers that have been issued and reissues new numbers, in numerical order, starting at 1.

The first 24 bits of the PET-system joint-access memory are examined for requests by the PET computer for the system to execute specific sub-routines; for example, the movement of 1000 bits of the database into the joint-access memory, or the overwriting of 1 byte of the database. This is the last non-time-shared routine, program execution continuing with the determination of queue length.

The PET Computer Software

The programs for the PET computer are written in BASIC, and it is anticipated that users will write their own programs to suit their particular needs. A number of programs have been written both for the traffic and engineering aspects of the EEQE.

Traffic Programs

There are 4 main traffic programs:

(*a*) The weekly statistics program, which gives the results achieved by the previous 15 shifts, plus the results to date of the current shift.

(*b*) The daily statistics program, which gives up to the minute results of the current shift, the results being updated every few seconds.

(*c*) A program to enable the various system parameters to be plotted in bar histogram form. Up to 4 graphs can be drawn simultaneously. The user stipulates the parameters that should be used to draw the different plots. The numerical values used to produce the graphs are printed at the side so that the values are to hand, and can be used if the scales make reading difficult.

(*d*) A program to generate a half-hourly print of virtually all system parameters.

Engineering Programs

There are 5 main engineering programs to

(*a*) identify the source of alarm conditions,

(*b*) give a detailed description of the states of the lines and operators,

(*c*) trace all calls within the system,

(*d*) set the calendar clock, and

(*e*) provide special faults investigation facilities, using a

machine-level program. (All communication is in hexadecimal.)

FUTURE POSSIBILITIES

Directory enquiry bureaux are of various sizes; some are smaller than that at Edgeley, and some are very much larger.

Smaller Bureaux

A reduction in the number of operators reduces the number of incoming junctions that can be catered for, because of the limit of 1·3 junctions per operator. Since the equipment is modular, a full rack housing is necessary, but only the appropriate number of operator's consoles, line circuit cards and matrix switches need be provided. The most cost effective reduction occurs when 18 or less operators (including transfer circuits) are required; this halves the number of line circuits required and divides the size of the reed matrix by a factor of four.

Metering

Since the system could possibly be used in applications other than directory enquiries, it may be required to meter calls; this facility is already provided as an option.

The PET Computer

At present, all programs for the PET computer are held on cassettes. This has the advantage that a large repertoire of programs is available, but has disadvantages in the time required to load them. It is possible to provide all programs on read-only memory (ROM) or ROM simulators and provide immediate access to any program. Alternatively, since the PET computer is a business system, many peripherals are available; for example, a floppy disk drive system could be used for both program and statistics storage.

CONCLUSIONS

The EEQE serves the purpose for which it was designed extremely well and compares favourably with other systems from a cost point of view. The prototype system has successfully handled over 1·25 million calls, demonstrating its ability to cope with large volumes of traffic. Both large and small systems can be served.

The transmission quality is a considerable improvement over the old system. Furthermore, the system fits well into modern office-type accommodation and, since no telephone exchange rack space is necessary, a non-operational building can be used.

ACKNOWLEDGEMENTS

The authors would like to express their thanks to the rest of the design team Messrs. C. P. Heald, C. J. Price, P. Gibbons and J. Harris of Manchester South Area maintenance staff. Thanks are also due to the installation staff who gave invaluable assistance, the traffic staff who helped with the design parameters, the supervisors and operating staff who cheerfully put up with much inconvenience during the installation and testing of the prototype equipment, and Messrs. F. W. Croft, W. Thompson and the Manchester South Area Board for having faith in the project.

British Telecom Press Notice

TELSTAR 20 YEARS ON

The twentieth anniversary of TELSTAR, the world's first communications satellite, which brought live television pictures direct from the USA to British Telecom's (BT's) earth station at Goonhilly Downs in Cornwall, took place in July of this year.

BT has been in the forefront of global space communications since that first experimental transmission on 11 July 1962, when Goonhilly was one of 3 earth stations—the others were in the USA and France—to pioneer space communications via TELSTAR. Since then satellites have brought news and pictures of major world events into people's homes, as they happen. These have included the Olympics, the Royal Wedding, the Pope's visit and more recently world-cup football, watched by hundreds of millions of people around the world. It is now commonplace for major events to be transmitted worldwide within seconds by satellite.

Today, 4000 communications circuits from the UK are linked by satellite, while two-thirds of the world's intercontinental traffic passes through the satellite network; so do Telex, data and facsimile calls, telegrams, television and even telephone and Telex calls to ships at sea. There are now more than 200 earth stations worldwide, with more than 300 antennas run by the 105-nation International Telecommunications satellite Organisation (INTELSAT), with 13 satellites hovering at about 35 890 km above the equator.

This year British Telecom announced that, in partnership with British Aerospace and Marconi, plans were being made to launch a British satellite to transmit nationwide communications by the mid-1980s, which would transmit direct to homes or businesses.

The potential of satellites as a means of communication was first envisaged by Arthur C. Clarke, the famous writer, who described a scheme for global telephone calls and television by satellite, in an article in *Wireless World* in October 1945. He also envisaged that satellites could be made to "hover" above any point in the equator. Put in the right orbit, at the right height, a satellite would circle the globe at a speed that exactly matched the rate at which the earth turned on its own axis.

TELSTAR—a satellite used for a year—was far from goestationary. Because it swept around in orbits at only 320–480 km above the earth every couple of hours, communication from earth stations was only possible for 20–30 min at a time, and the 1100 ton antenna at Goonhilly Downs had to be nimble enough to track it.

In July 1965, EARLYBIRD went into geostationary orbit over the Atlantic to provide the world's first commercial communication satellite service.

Viscount—A New Basic Telephone

R. R. WALKER, B.SC.(ENG.), C.ENG., F.I.E.E.†

UDC 621.395.6

Viscount is a new electronic telephone that has been developed for British Telecom as a joint venture by Standard Telephones and Cables PLC and British Telecom Research Laboratories. This article describes the origins of the development of the electronic telephone, charts its progress, and highlights some of the significant features of this telephone, which is now in production. Another electronic telephone, the Statesman, will be described in a later issue of the Journal.

INTRODUCTION

Two new basic-range telephones, known as *Viscount* (Telephone No. 9500) and *Statesman* (Telephone No. 9000), are being introduced by British Telecom (BT) into the UK network during 1982. Although they differ in styling and in internal construction, they are similar in performance and in the facilities that they offer to customers.

Both telephones are the product of a conviction that BT and the UK telecommunications industry needed low-cost, high-quality electronic telephones that could be produced in very large quantities to provide a home-base for exports. Coupled with this was the certainty that conventional development timescales were unnecessarily, and quite unacceptably, long.

However, from this starting point the development paths of the 2 instruments diverged. Viscount was developed for BT by Standard Telephones and Cables PLC (STC), whereas Statesman was developed as a private venture by TMC Ltd., The General Electric Company Ltd. and Plessey Company PLC.

With hindsight this may seem like wasteful duplication of scarce development effort, yet it has yielded significant advantages for all the parties concerned. BT has gained competitive sources of supply and different design philosophies to draw on; and its customers have been given the choice of standard telephones.

DESIGN CRITERIA

An electronic telephone can be loosely defined as one in which the 3 functions of transmission, signalling and calling are realised by active circuits rather than by the passive induction coil of traditional telephones and electromechanical dials and bells. The possibility of such telephones has existed for many years, and several prototypes were demonstrated as laboratory exercises during the 1960s. They were of little further interest until the availability of large-scale integrated (LSI) circuits brought costs down.

By 1978, a few electronic telephones using LSI circuits were in service in various parts of the world. Their prime cost was still above that of conventional telephones, but there were indications that the conditions necessary for the development of a low-cost electronic telephone were being created.

Design criteria were, therefore, laid down in 1979 for a basic electronic telephone to replace the current standard telephone (Telephone No. 746).

(*a*) It was to be the simplest member of a possible family of electronic telephones providing the lowest achievable cost of ownership; it was to give improved and more consistent transmission performance.

(*b*) It was to have a linear microphone, press buttons and a tone caller (with no option for a dial and a bell), so that

(*i*) the physical design should not be constrained by dial and bell;

(*ii*) all components could be mounted on a single printed-wiring board (PWB) which should be suited to automated assembly;

(*iii*) press buttons would be available for multi-frequency (MF) signalling; and

(*iv*) it would pave the way for any future changes in calling signals.

Extra facilities, above those of the basic telephone function, were not to be included if they added to the cost, but the design was not to exclude their later addition.

These criteria all seem obvious and innocuous; it may, therefore, be worthwhile to set down some of their implications.

Low cost of ownership implies a balance between initial cost and maintenance costs. Broadly, it appears right to aim for the same standards of construction as are used generally in good quality consumer goods.

Automated production is an important consideration. The unit cost of items produced by an automated production line will be high compared with those from a labour-intensive line until capital costs have been recovered. Thereafter they should be lower. More important, though, are the savings that are possible by running an automated line on 2 shifts and thus obtaining economies of scale.

In the production of telephones, as in so many other items, the UK cannot compete with the low labour costs of some other parts of the world. By 1979, telephone production in the UK was in the classic situation that had led to rapid decline and virtual demise in so many other industries: as monopoly buyer, BT had scarcely varied its design requirements in 20 years. Compelling reasons of public demand, economics or technical advantage to make radical change necessary did not exist. Nor did the programme of orders for telephones help to establish a sound industrial base: over a period of 20 years, annual orders had varied between 0·5 million per annum and 2·5 million per annum in apparently random manner.

Two other aspects of BT's current standard 700-type telephone are worth noting. It is a most elegant piece of engineering design, and every component seems to serve several functions; cost-reduction exercises over the years have achieved a cost decline, in real terms, of 7% per annum from 1959 to 1975[1].

Another aspect to notice is that individual telephones are virtually immortal. Most recovered telephones are repaired and refurbished to reappear as good as new. This may not be done in future if the "throw away" trend that is general in consumer goods is adopted for telephones.

DEVELOPMENT SEQUENCE

There is a time-hallowed sequence of development in engineering about which engineers are seldom entirely honest; the time taken to obtain authority and negotiate contracts tends

† Research Department, British Telecom Headquarters

TABLE 1
Development Sequence

Activity	Elapsed Time (Years)
Internal discussions on requirement	Any length
Write specifications and market requirements	1
Prepare and send out tender documents	0·5
Contractors prepare tenders	0·25
Adjudicate tenders	0·25
Place development contract	0·5
Development	1·5
Trials	0·5
Place production contract	0·5
Production	1·5
Trials of production items	0·5
Total time to start full-scale production	7+

to be glossed over. The sequence can show many variations; in the case of a telephone, the critical path might be similar to that shown in Table 1.

Apart from its protracted length this type of programme has several unacceptable features.

(*a*) Specifications are written with little reference to the needs, abilities and experience of industry.

(*b*) The programme is discontinuous: there are several lengthy periods when development teams have little to do.

(*c*) Authority for production is not sought until the programme has been running for 5 years; by that time top management is left with few options.

Viscount Development Sequence

In mid-1978, British Telecom Research Laboratories (BTRL) spent 6 months in investigating the techniques, the advantages and the economics of electronic telephones, and in surveying the industrial activity in these areas in the UK and elsewhere.

The study concluded that an electronic telephone with better performance and reliability than a conventional telephone was then an economic possibility, but that little further sensible progress could be made without the involvement of industry.

During December 1978 and January 1979, BT and industry carried out intensive studies during which the design criteria already outlined were agreed and a programme for development and production was laid down in some detail; also target unit costs for the new telephone were agreed. Basically, the study attempted to answer 2 questions:

(*a*) what was the shortest possible time in which a cost-effective electronic telephone could be brought into production; and

(*b*) how could this be achieved?

The answers were

(*a*) that a definition contract, of about 2 months duration, should be let with a selected firm in order that a specification of performance and facilities might be jointly agreed and that a production timescale and a ceiling unit cost for the telephone might be agreed; and

(*b*) that the definition contract, if successful, be immediately followed by a combined development and production contract. This contract should assure the selected firm of a bulk order provided that the performance specification was met, the production timescale was adhered to, and the ceiling unit price was not broken.

Given these conditions, bulk production was forecast to start within 30 months of the letting of the main contract and figures were given for the unit price.

A period followed, inevitable in a large organisation that was adapting to new ways of working, during which BT decided whether it really needed an electronic telephone and whether this was the way to proceed. By August 1979, the project had been authorised on the lines indicated.

A definition contract was placed with STC by the end of September and completed by the end of the year; the main development began in January 1980.

A contract to cover the definition phase enables the whole project to proceed in a disciplined manner. Everyone concerned is aware that all decisions, both large and small, have to be taken within a contractual period of time.

Although the normal problems were encountered during development and production, at the end of the day all the performance targets were met; production started in May 1982; and the ceiling unit price quoted at the beginning of 1979 was, allowing for inflation, comfortably undercut.

One decision, taken in 1980, had a significant influence on the unit prices. This was the recognition that a telephone is an item of consumer electronics and should be engineered to the appropriate standards, and not to those that may be proper to a telephone exchange or a piece of military hardware.

Development and production were entrusted to STC with BTRL maintaining a close involvement throughout to manage the project on behalf of BT.

For comparison, the development sequence of the Viscount was as shown in Table 2. Although this is certainly an improvement on previous timescales, it seems likely that it can be further improved.

TABLE 2
Viscount Development Sequence

Activity	Elapsed Time (Years)
Internal research and development	0·5
Obtain agreement and authority	0·75
Write specifications	0·25
Develop and tool for production	2·25
Total time to start full-scale production	3·75

VISCOUNT CASE DESIGN

Design of the case for the Viscount was the responsibility of STC, whose designer was given a detailed schedule of requirements. Some of these have already been mentioned; 2 additional requirements were significant: firstly, to produce a design that would be readily adaptable for desk or wall mounting; and secondly, to aim for a style that would not look dated by 1985.

Seven alternative designs were produced. Joint consideration by BT and STC reduced this range to 3 designs, which were made up as hollow glass-fibre models equipped with microphones and receivers. These models were used in subjective tests under controlled conditions, and the results showed that there were no engineering reasons for any of the designs to be rejected. The final selection of one from the 3 designs was made by a BT management decision at a meeting lasting 5 minutes. This decision was given on schedule within the development timetable.

Figs. 1–5 show details of the telephone and its assembly. It consists of 4 main mouldings: 2 halves for the body and 2 halves for the handset. These are all in acrylonitrile/butadiene/styrene (ABS). Numerous design features have been incorporated into these mouldings in order to simplify assembly. These features include:

(*a*) simple split line to reduce problems of case alignment,
(*b*) single-screw fixing,
(*c*) clip-in PWB with float to align keypad with cover,

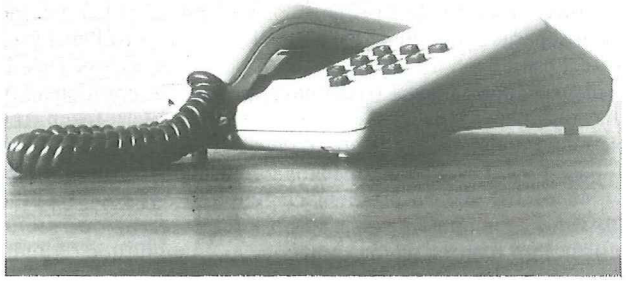


FIG. 1—Viscount, Loop-disconnect model

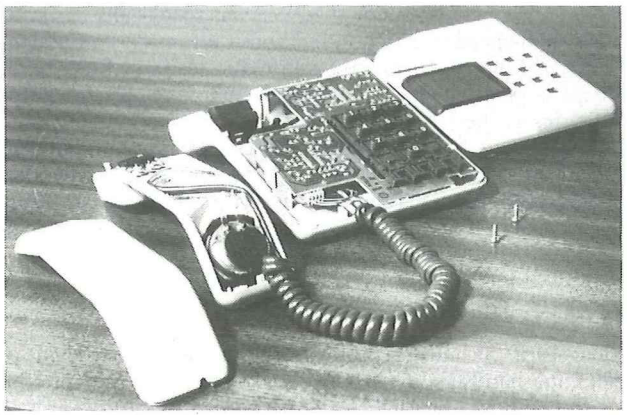


FIG. 3—Interior of case and handset

(*d*) clip-in tone caller transducer,
(*e*) clip-in volume control shutter,
(*f*) cord entry on split line, and
(*g*) cords fixed by a labyrinth (thus no grommets are required).

A plastic moulding of this complexity, which is suitable for mass production, is the result of a great deal of development. The minor projections, clips and fittings have all been designed and modified to ensure perfect fit and alignment. There is as much art as science in this process.

MECHANICAL DESIGN FEATURES

Keypad

The keypad used in the press-button version of the 700-type telephone had over 300 piece parts; that used in Viscount has 4: a button frame assembly, a conductive rubber key mat, a polythene insulating sheet and the printed circuit on the main PWB.

The use of conductive rubber for the keypad contacts was a novel departure for BT and was made possible because the integrated complementary metal-oxide semiconductor (CMOS) logic circuits used for either loop disconnect or MF4 signalling do not require low ohmic contacts typical of conventional dial telephone designs. Indeed, reliable operation is obtained for a contact resistance of several thousand ohms.

Careful mechanical design of the rubber actuator controls the force/travel characteristics of the buttons to ensure a reliable collapse action for the keypad buttons. This is used to advantage in MF4 signalling variants of the telephone to control the minimum duration of the signalling tone bursts.

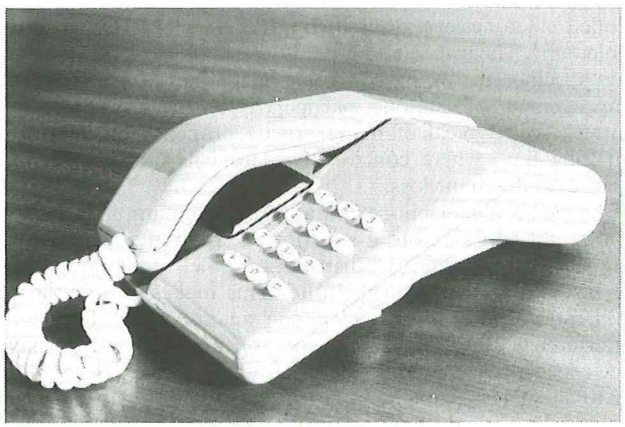


FIG. 2—Viscount, MF model

Considerable effort was expended on the selection and testing of the components for the keypad assembly, particularly the rubber elastomer mat, and extensive life tests were conducted to ensure that the collapse action of the mat was maintained to over 350 000 operations. Results of the test programme have shown some small initial reduction in the operating pressure followed by a stable plateau which extends beyond 350 000 operations.

Separate tests on the frame which holds the individual buttons were stopped when, after 3 million operations, no failures had been found.

The use of smaller buttons for the keypad, albeit at the conventional spacing, was a further departure from tradition and extensive human factor tests were conducted to ensure that neither this nor the characteristics chosen for the elastomer mat gave rise to any dialling problems. Results showed no significant difference in keying errors from conventional keypads.

Printed-Wiring Board

For minimum cost, a single PWB is required to hold all the components, but the shape of the case dictates the use of 2 boards. These are made as a single item and then cracked along a pre-marked fault line so that the boards can follow the shape of the case.

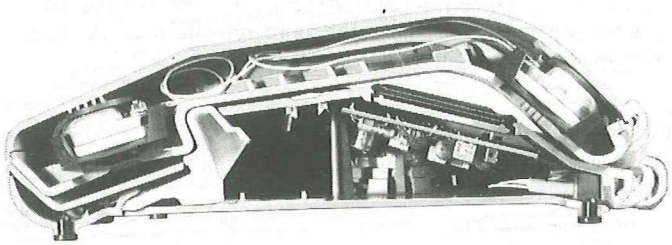


FIG. 4—Section through case at handset

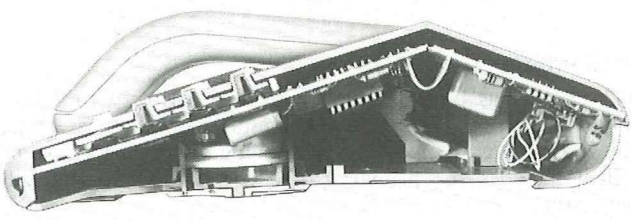


FIG. 5—Section through case at keypad

The component layout on the PWB was specifically designed to aid high-speed production methods (automatic component insertion, flow soldering and automatic testing). Each component is positioned to ensure adequate clearance for automatic insert heads, and minimal positioning time during assembly sequences. The complement of axial and radial-lead components was closely defined by the throughput schedules related to automatic component insertion machine operating speeds and economic factors controlling the number of machines being used.

Handset

There is a certain mythology surrounding the design of telephone handsets. This is said to be a drawn out process not to be undertaken lightly. There was some truth in this in the days when each iteration in the design had to be checked by lengthy subjective tests. Today, with automated test gear, computers and the results of 50 years of making objective and subjective measurements, it is possible to reach a first opinion on a handset in a working day.

Subjective tests are still needed because there may be something about the shape of a handset or its weight distribution that causes people to hold it in an attitude that precludes good coupling between the head and the microphone and receiver. But the ground work can be done by objective measurement in the laboratory, providing that the laboratory still contains someone with a basic knowledge of acoustics.

Several iterations of the handset design were necessary before the required acoustical performance was achieved. The modifications at each stage were all minor, although critical; they involved such things as the number and size of the holes in front of the transducers, the seal of the transducers in the handset and the acoustical baffling provided by the internal ribs.

The microphone and receiver used in the initial launch of Viscount are both based on a receiver that has been in production for some time—a rocking-armature device. There were good practical reasons for this choice and it has proved possible to produce a telephone that fully meets all design requirements. Yet it must be said that handset design, particularly as regards freedom from howl round, would be eased if both transducers were not of the same design.

Tone Caller Attenuator

The volume of sound produced by the tone caller can be varied by the user over a wide range. This variation is controlled by a simple mechanical shutter underneath the telephone which is a cheaper and more reliable item than an electrical volume control.

ELECTRICAL DESIGN

For simplicity the design can be broken down into the following functional blocks:

(*a*) Line interface,
(*b*) Transmission,
(*c*) Tone caller,
(*d*) Register recall,
(*e*) MF signalling, and
(*f*) Loop disconnect signalling.

Line Interface

The circuit has been designed to be compatible with 3-wire interconnection of telephones in simple plan systems. Thus, the incoming exchange line is terminated on a line jack unit which includes the primary surge protection and the bell capacitor.

Secondary protection is provided within the telephone against high voltages on the line. A poling bridge is also provided so that the telephone is independent of line polarity.

An area of considerable concern when low-voltage electronic circuitry is introduced into telephones is the ability of the circuit components to withstand high voltage surges on the line. Certainly the primary protection afforded by the gas discharge tube in the line jack unit is insufficient to protect the telephone against even modest surges (its task is to protect the low-level (secondary) protection components). The residual lower energy disturbances which reach the telephone must be clamped to levels which will cause no damage to active circuits normally operating at less than 10 V.

One of the major problems facing the designers of the electronic telephone was the almost total absence of useful information relating to the frequency and magnitude of high-energy surges on the telephone network. Only one fact was clear—700-type telephones had a good survival record under these conditions. The aim therefore was to design Viscount to be no less robust than the 700-type. This has been achieved with the use of a few low-cost components.

Customer safety was another important design parameter and in Viscount the customer is protected from dangerous voltages appearing on the telephone. The standard of protection is approximately the same as that given by double-insulated mains equipment.

Transmission

The speech transmission function of the Viscount is realised with a single bipolar integrated circuit (IC), the STL 106, designed by Standard Telecommunications Laboratories Ltd. (STL). The IC, the latest in a series designed by STL, provides the main functions of transmit and receive amplification, 2-wire-to-4-wire conversion (the hybrid function) and regulation. The IC, which is also used for interfacing an MF signal to line (in the MF version of the telephone), incorporates a low-voltage power supply to operate a CMOS MF4 tone generator. The use of an active transmission circuit offers the designer far greater freedom to control independently the send and receive sensitivity of the telephone, its regulation, output impedance and hybrid balance impedance. Choice of the latter is particularly important for controlling the level of sidetone obtained with the telephone under various network conditions.

A detailed study was undertaken within BTRL to determine the values for the sensitivities and impedances of the telephone speech transmission circuit most appropriate to the existing and future UK telephone network. Use was made of computer models of the telephone network and of customer's subjective reactions (CATNAP[2]) to examine the performance of hypothetical electronic telephone parameters over a wide range of circuit conditions and terminations. Whilst there can be no optimum set of parameters for a telephone in an evolving network, values can be derived that, on average, give improved transmission performance when compared with those of existing telephones. The significance of well controlled sidetone levels was highlighted in a recent article by Coleman[3]. The transmission parameters adopted for Viscount and specified for future electronic telephones offer significant improvement of sidetone, particularly on the short line/high current feed typical of many private branch exchanges and on long lines where control of sidetone is more important than overall circuit loss.

An electronic telephone contains high-gain amplifiers. Even if it is not connected to a superior external antenna (such as the lead-in wire from the distribution pole) the handset cord serves as a reasonable substitute. This makes it essential to take precautions in the telephone against radio frequency interference (RFI). Some 10 components in Viscount have been specially included to provide radio-frequency decoupling or to act as low-pass filters. Particular attention has also been paid to the layout of the tracks on the PWBs.

There are no established standards or tests for RFI sup-

pression in telephones although work is in progress at BTRL on this subject.

Despite all reasonable precautions within the telephone some situations will undoubtedly arise, particularly when in close proximity to medium-wave broadcast transmitters, where breakthrough of radio programmes will cause annoyance. It is probable that special kits of suppressors will be needed for use in these exceptional circumstances, and development of these is underway.

The telephone handset contains 2 rocking armature transducers of 600 Ω impedance but with different internal damping; they are mounted in rubber washers specially designed to give a good acoustic seal and to minimise mechanical coupling.

Tone Caller

The tone caller uses a commercial IC, the AMI S2651A, and a rocking armature transducer. Power for the circuit is obtained by full wave rectification of the ringing voltage.

The IC contains a relaxation oscillator with a nominal frequency, f_o, of 6667 Hz. This frequency is internally divided by 8 and 10 and the resulting 2 frequencies are switched at a rate of $\frac{f_o}{320}$ before being amplified and fed to the transducer.

The choice of tones for a calling signal involves both aesthetic and scientific judgements. Amongst the latter are such considerations as localisation of the signal, penetration through partitions and closed doors and audibility to older people with reduced sensitivity to high-frequency sounds.

Register Recall

This switch, which is fitted only to MF versions of the telephone, provides a timed break of the line of between 50 and 100 ms. Some effort was devoted to devising a mechanical switch that would give a break of this duration, but eventually an electrical method using 2 extra transistors was adopted.

MF Signalling

The MF signalling circuit is conventional and basically simple. A commercial IC, the Mostek MK 5089, generates the required tones digitally by division from a crystal-controlled oscillator running at 3579 Hz. These tones are amplified in the transmission circuit and passed to line. At the same time a confidence tone is fed back to the telephone receiver.

Loop Disconnect Signalling

Loop disconnect signalling is ideally suited for generation by a dial. If carried out by a keypad, a number of problems become apparent:

(*a*) during the disconnect part of the pulse, no power is available to the telephone;

(*b*) the circuit is required to switch a supply potential of 50 V in an inductive circuit; and

(*c*) since the user can key in numbers much faster than they are sent to line, it is necessary to store the entire number within the telephone.

A commercial IC, the DF320A, together with more external components than those required for MF signalling is used. In particular, a high-voltage pulsing transistor is included.

Timing of the pulses is controlled by a crystal oscillator which uses the same crystal as the MF version. Conveniently, this crystal is one designed to set the colour-burst frequency in US television receivers.

EVOLUTION

Viscount has been designed as a low-cost basic telephone; and the same is true of Statesman, which will be described in a later article.

Over a number of years this *Journal* has carried articles on basic telephones; namely, in 1929[4], 1938[5], 1959[6] and 1981[7]. If history were to be repeated it could be predicted that the new electronic telephones would, with minor modifications, give service until the end of the century. However this is highly unlikely to happen. Indeed, the forces of change can already be discerned in 3 areas: in descending order of certainty, they are, technology, competition and customers' requirements.

Advances in solid-state physics produced the IC. The telephone described in this article contains about 1000 active devices. A telephone which also provides some number stores and a display will contain about 10 000 active devices. At the moment, its cost is greater than that of a basic telephone, but this cost difference will be reduced.

By the end of the 1980s, it will be possible to put a million active devices into every telephone for little more than it costs to produce today's basic telephone (albeit the means of accessing this computing power may have to be paid for). How this potential is used depends on a number of variables; for example, on how the network evolves to follow or to lead the increasing abilities of its terminals (even in 1990 there will probably still be Strowger exchanges in the UK); on what BT's customers want; and on the accidents of history.

Competition is surely going to lead not just to fashion changes in telephones, but to a race to offer the most facilities for the least cost. It is going to lead to even shorter lead times from development to production; and to more efficient ways of getting telephones from the factory to the customer. Other industries have felt the effects of this type of competitive market; opinions will differ about who will benefit from it the most.

There is probably a substantial number of customers for telephones who are prepared to pay for an increasing range of extra facilities with the telephone. Some of these facilities will just make it easier for the telephone to be used; others will be part of a wider range of communication links. This suggests that Viscount, and similar telephones, will have to evolve if they are to survive for a long time in the market place.

ACKNOWLEDGEMENTS

The development of Viscount has been a co-operative effort by STC, STL and BT. It has fallen to the person who did least to record and applaud the efforts of those who have done the real work. Photographs by courtesy of STC.

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The Emerging Digital Transmission Network

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UDC 621.394.4 : 681.327.8

Studies of the application of digital techniques to the transmission and switching elements of the British Telecom (BT) telecommunications network have shown that considerable advantages and economies over equivalent analogue methods can be achieved. Digital transmission allows integrated transmission of voice, data and visual services over a common bearer network. This article describes the modernisation of the BT transmission network by conversion to digital operation using a range of digital transmission systems working over copper cables, optical fibre cables and microwave radio. This modernisation will result in a telephone service of high quality offering enhanced facilities as well as creating an integrated services digital network to meet the more complex non-voice customer requirements of the future.

This article is based on a paper presented at the International Computer Communications Conference held at the Barbican Centre, London, in September 1982.

INTRODUCTION

Data transmission in the UK has been in a dramatic expanding and evolving situation since the introduction of Datel services by British Telecom (BT) in 1965. Both voice-band private circuits and the public switched telephone network (PSTN) have been extensively used for data transmission. Customer demand for new and improved services operating at higher bit rates has been met by more complex designs of modems which can cope with the transmission impairments of the analogue transmission network.

However, rapid advances in technology are making available a comprehensive range of sophisticated new customer-located products to augment the basic telephone for business and social purposes. The increasing size and complexity of computing systems associated with data line networks call for higher throughput of information and the provision of intelligent terminal equipments.

Fig. 1 shows the growth in services offered by BT to date and those likely to be available during the 1980s. Customer information type services are leading towards a convergence of voice, data, text and facsimile services where boundaries between different user requirements are merging and becoming less distinct. The restrictions of the present analogue transmission network and its inability to cope economically with the changing data requirements were taken into account in the studies of applications for digital techniques to both the transmission and switching elements of the network. To meet the long-term requirements for improved customer facilities and quality of service, as well as giving operational and economic advantages, it was concluded that a digital transmission network offered all the essential characteristics.

(*a*) A common transmission path with a high transmission performance virtually independent of distance can be used for all voice, non-voice and wideband services.

(*b*) Integrated digital switching and transmission can be provided for speech and data at rates up to 64 kbit/s.

(*c*) New services and terminal devices will generally exploit digital techniques so that the adoption of a digital network will avoid expensive high performance modems and digital/analogue conversion processes.

(*d*) Supplementary facilities can be readily provided to augment the basic telephone service and cope with a wide and expanding range of new information services.

Consequently, the BT network is being modernised by replacing existing analogue plant with digital switching and transmission systems, thus forming an all-purpose integrated digital network (IDN) between local exchanges which will provide the overall flexibility to meet the ever changing needs expected in the future.

This article outlines the various digital transmission systems in the course of development and production, from the low-capacity pulse-code modulation (PCM) systems on symmetrical-pair type cables to the high-capacity high-bit-rate systems on coaxial cable, optical fibre cable and microwave radio. Also mentioned are some of the future developments for further improving the network capability and extending digital transmission into the local network to provide completely digital customer-to-customer links as the basis of an integrated services digital network.

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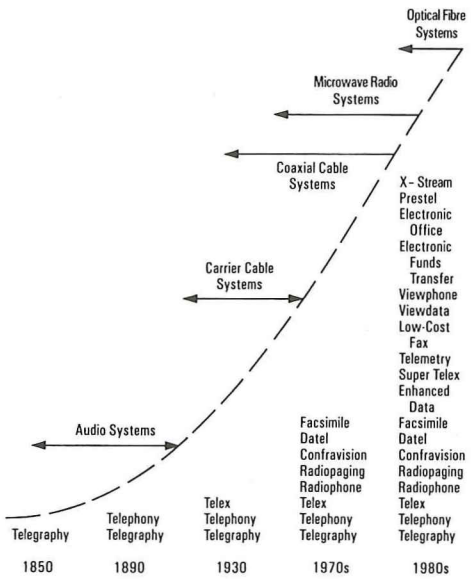


FIG. 1—Growth in services

GENERAL CONFIGURATION OF EXISTING TRANSMISSION NETWORK

As the telephony and Telex networks existed before the demand for data transmission, it was natural for data traffic to be routed over existing telephony transmission line plant and the present telephone and Telex services fully exploited to provide economic data communication channels.

The use of a shared network rather than a purpose-designed network incurs penalties in that the transmission character-

istics of the telephony channel must be taken as the starting point for the development of the data modem—the interfacing device used to convert the customer's binary-coded signals into the analogue signals that can be handled by the telephony circuit. Where the modems are intended for operation over PSTN connections, correction must be introduced to compensate for the network impairments that cause errors in data transmission, but do not affect speech communication. Restrictions arise in the use of particular frequencies in the available bandwidth, but for data transmission rates of up to 1200 bit/s, simple modulation techniques using frequency-shift keying (FSK) have proved to be adequate.

For higher transmission rates, more sophisticated modulation techniques using phase-shift keying (PSK) or combinations of amplitude and phase modulation must be used to compress the information to within the bandwidth available on private speech-band circuits and the PSTN. To increase the bit rate without exceeding the permissible bandwidth limitations of the transmission path requires the use of more complex modems, which incurs a higher cost. Datel service modems incorporating adaptive-type equalisers and medium- and large-scale integrated circuits are currently available for operation at a range of speeds up to 9600 bit/s over voice-band circuits and at 40·8, 48, 50, 64 and 72 kbit/s over group-band circuits. The present range of BT modems is shown in Table 1. At present, there are about 94 000 BT modems in operational use, 60% of which are connected to the PSTN.

There are considerable network constraints in achieving further improvements in bit rates over the present analogue plant and digital alternatives offer the more effective solution in terms of bandwidth utilisation, flexibility and economics in meeting the digital private-circuit network requirements of the future.

In the BT main network, cable and radio transmission systems provide the traffic circuit routes which interconnect about 370 group switching centres. Over the years, increased traffic has demanded that higher circuit capacities be available from transmission systems. Technology has evolved to meet these needs and at present the basic 12-circuit carrier group, assembled by frequency-division multiplex (FDM), is the basis of the larger multichannel assemblies forming the FDM hierarchical structure of supergroups and hypergroups used for transmission over coaxial cable or microwave radio.

In changing to an all-digital time-division multiplex (TDM) network, a major objective is to have transmission systems offering comparable circuit capacities to the present FDM systems so that maximum use can be made of the existing assets in terms of cables, underground equipment housings, power-feeding systems, surface intermediate stations and radio towers. These aspects have been given full consideration in the design and development of digital systems to meet the requirements for speech and data transmission.

NETWORK MODERNISATION STRATEGY

The main aims of the strategy for modernisation of the

TABLE 1
Summary of Datel Services

Service	Modem No.	Transmission Speed (bit/s)	Field of Application	Remarks
Datel 200	2 13 21	200 300	PSTN or 2-wire PC	200 bit/s assured via PSTN
Datel 600	1 20 22	600/1200 with 75 return channel	PSTN or 2-wire or 4-wire PC	Asynchronous half-duplex on PSTN and 2-wire PC
Datel 1200	27 28 29	1200	PSTN	Synchronous or asynchronous at 1200 bit/s
Datel 2400	7B	2400	4-wire PC	Stand-by via PSTN 600/1200 bit/s half-duplex with 75 bit/s backward channel
Datel 2400 Dial Up	7C	2400	PSTN	Synchronous half-duplex at 2400 bit/s with fallback to 600 or 1200 bit/s half-duplex
Datel 2412	12 31	2400	PSTN or 4-wire PC	Synchronous full duplex at 2400/1200 bit/s on 4-wire PC with stand-by on PSTN at 2400/1200 bit/s half-duplex and backward channel at up to 150 bit/s asynchronous
Datel 4800	11	4800	PSTN or 4-wire PC	Synchronous full duplex on 4-wire PC. Stand-by on PSTN synchronous half-duplex at 4800/2400 bit/s
Datel 4832	24A	4800 3200	4-wire PC	Synchronous full duplex on 4-wire PC at 4800/3200 bit/s. Stand-by at same bit rates on 2 PSTN lines
Datel 9600	30	9600	4-wire PC	Synchronous full duplex at 9600 bit/s with fallback to 7200 or 4800 bit/s. Stand-by at same bit rate on 2 PSTN lines
Datel 48K	8 9 25	40·8 k 48 k 50 k	4-wire group-band circuit (48 kHz)	Synchronous full duplex
Datel 64K	35 36	48 k 50 k 60 k 64 k 72 k	4-wire group-band circuit (48 kHz)	Synchronous full duplex

PSTN: Public switched telephone network PC: Private circuit

network are to replace completely the principal analogue network elements comprising large local exchanges, trunk and tandem switching, and trunk transmission with digital equivalents by the early-1990s. Replacement of the other elements, such as small Strowger exchanges, crossbar exchanges and the remaining parts of the junction network will be completed some 10 years later.

Implementation of this strategy requires the provision of a digital transmission network to interconnect all primary switching centres within about 10 years and a complete national replacement digital transmission network to interconnect all local exchanges within about 20 years. The methods to be adopted to achieve these objectives take into account the intention to exploit the availability of digital plant on routes provided for telephony, and, by the introduction of a limited quantity of specially developed data transmission equipment, to enable digital private data circuits to be offered between major city centres as early as possible. These new *X-Stream* services: *KiloStream* for services below 1 Mbit/s; *MegaStream* for services at 1 Mbit/s and above are to provide an overlay digital network until the introduction of *SwitchStream 2*—the fully integrated services digital network (ISDN).

MegaStream is available now and KiloStream will be introduced in 1983, offering digital services at speeds of 2·4, 4·8, 9·6, 48 and 64 kbit/s.

RANGE OF DIGITAL TRANSMISSION SYSTEMS

A wide range of digital transmission systems and higher order multiplexing equipment is to be used to modernise the network. The different systems, circuit capacity and the dates for their introduction into service into the network are shown in Table 2.

Low Capacity Systems

The 2·048 Mbit/s digital line system (DLS), which conforms with the CCITT† requirements, is intended primarily for use in the junction network, but can be extended to customers' premises to provide point-to-point private circuits for operation at this bit rate. The latest general purpose PCM primary multiplex (MUX) provides for input signals in both analogue and digital form to be multiplexed together in time division to provide a 2·048 Mbit/s composite digital output signal.

† CCITT—International Telegraph and Telephone Consultative Committee

TABLE 2
Range of Digital Transmission Systems

Equipment or System Title	Circuit Capacity	Service Dates
2 Mbit/s digital line system	30	1979
120 Mbit/s digital line system	1 680	1980
8 Mbit/s digital line system	120	3/83
140 Mbit/s digital line system	1 920	8/82
140 Mbit/s optical fibre system (proprietary)	1 920	6/82
140 Mbit/s optical fibre system (standard)	1 920	7/85
11 GHz digital radio-relay system (5 + 1 bothway channels of 140 Mbit/s)	9 600	6/82
4 and L6 GHz digital radio-relay system (7 + 1 bothway channels of 140 Mbit/s)	13 440 per band	7/85
19 GHz digital radio-relay system		
(6 bothway channels at 2 or 8 Mbit/s)	720	1981
(6 bothway channels at 140 Mbit/s)	11 520	1986
Multiplex equipment		
2–8 Mbit/s and 8–120 Mbit/s		1980
8–34 and 34–140 Mbit/s		6/82
Codec equipment		
Supergroup	60	7/84
Hypergroup	900	5/84

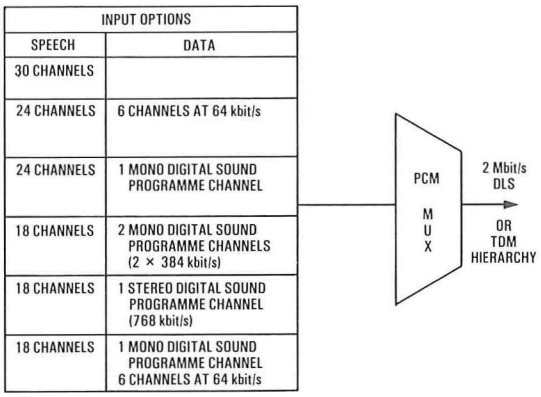


FIG. 2—General purpose multiplex

This equipment provides for a combination of services to suit local circumstances as shown in Fig. 2 by the use of a range of input tributary cards. Where larger groups of 64 kbit/s are required for digital private circuit network applications, special dedicated primary MUX will be used.

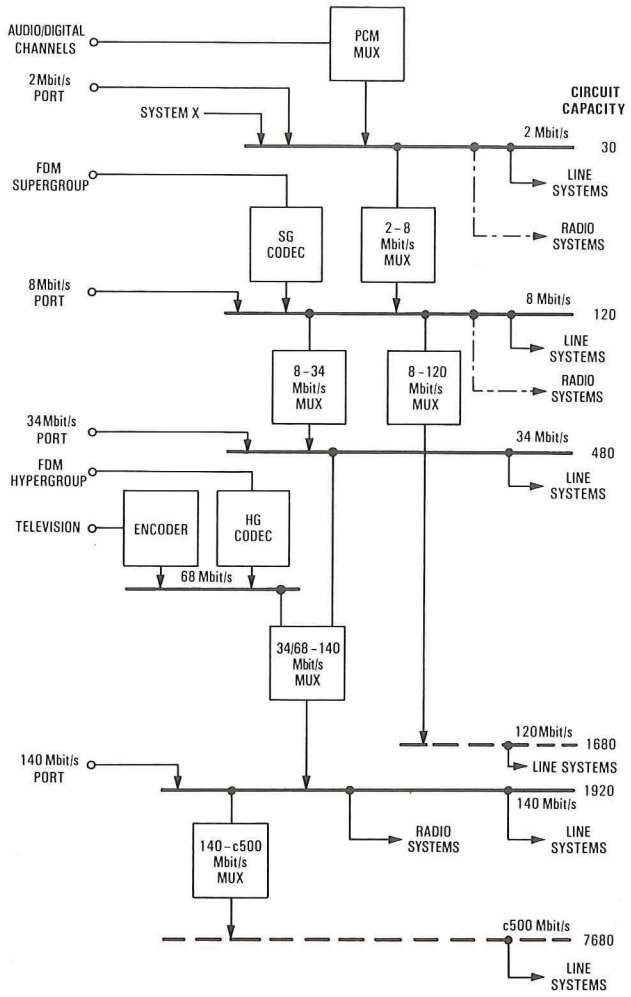
High-Capacity Systems

The first high-capacity digital system for the main network was designed for operation at a rate of 120 Mbit/s on existing 1·2/4·4 mm coaxial cable. Each system provides a capacity of 1680 telephony circuits assembled via 2–8 Mbit/s and 8–120 Mbit/s multiplex equipment. Only a limited number of these systems are being installed in the network as BT subsequently adopted the CCITT recommended hierarchical structure of 34 Mbit/s and 140 Mbit/s rates. Consequently, all subsequent systems have been developed for operation at these rates. As 140 Mbit/s is the rate considered most suitable for the modernisation of the main network, systems have been designed for operation at this rate on coaxial cable and microwave digital radio-relay systems (DRRSs) firstly in the 11 GHz band and later in the 4 GHz and lower-6 GHz bands. Development work is also in hand for DRRSs operating in the 19 GHz band at 140 Mbit/s for the main network and at 2 Mbit/s and 8 Mbit/s for junction and local network applications.

Multiplexing equipment has also been developed to provide 8–34 Mbit/s and 34/68–140 Mbit/s digital multiplex. The TDM hierarchical structure is shown in Fig. 3. The 68 Mbit/s entry port provides for the hypergroup codec and digital television interfacing in the future.

Optical Fibre Systems

The above systems are primarily designed to fit existing networks and to establish a digital hierarchical structure. However, serious consideration has been given to the use of optical fibres as an alternative transmission media to copper conductor cables. In the main network, optical fibres have to compete with coaxial pairs carrying 140 Mbit/s systems, and optical fibre systems for operation at 140 Mbit/s have been developed for this application. After several successful field-evaluation exercises by BT and Industry, BT has now gained sufficient experience and confidence to order a substantial quantity of essentially proprietary optical fibre systems for installation in the main and junction networks by 1985. The initial order was for a total of 34 systems on 15 different routes using a variety of fibre cables operating at a wavelength in the region of 850 nm. Six 140 Mbit/s systems on 3 routes, four 34 Mbit/s systems on 2 routes and two 8 Mbit/s systems on one route are for main network use, the remaining twenty-two 8 Mbit/s systems are for short-haul application in the junction network. The initial experience with these systems, due for completion in 1982, has encouraged BT to place a further order for a much larger quantity of similar



FDM: Frequency-division multiplex HG: Hypergroup
MUX: Multiplex SG: Supergroup

FIG. 3—TDM hierarchy

systems involving 224 systems on 65 routes in various parts of the country. Some of these systems will use the longer wavelength of 1300 nm on graded-index fibre. One of these routes is over 200 km in length. Another route, more than 27 km in length, will use monomode fibre equipped with a 140 Mbit/s system operating without any intermediate regenerators. This is significant because a system repeater spacing of 30 km would mean that, for most routes, repeaters could be housed in surface stations and power feeding along the cable to dependent regenerators would not be necessary, thus reducing capital costs and improving reliability.

The economic benefits predicted for optical fibre systems compared with coaxial cable and radio system equivalents are indicated in Fig. 4. Furthermore, because of their longer repeater spacing, optical fibre systems promise to be easier to install and maintain than digital systems on metallic pairs. Consequently, to derive the maximum potential economic benefits, optical fibre systems are being introduced as early as possible in the network modernisation programme. In the longer term, optical fibre systems have enormous potential to provide very-high capacity digital links in an economic manner. Such systems operating at 565 Mbit/s and 1 Gbit/s or using wavelength-division multiplexing to transport several systems on one monomode fibre will require very few repeaters and will be ideally suited to provide the large communications capacity required by future information and visual services.

Because the proprietary systems are being purchased as cable and equipment packages, a number of different designs

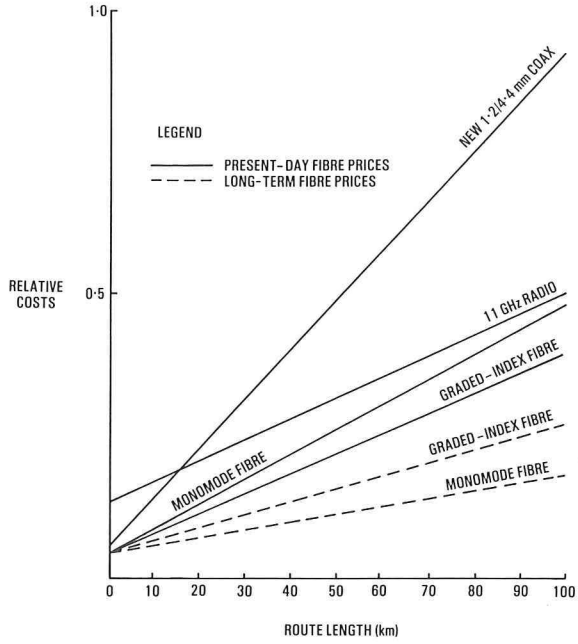


FIG. 4—Cost comparisons

of system has resulted which could impose limitations on the exploitation of the spare fibres in the cables and cause other operational problems. Thus, BT's efforts are currently directed towards the introduction of some standardisation of the optical fibre cable characteristics so that standard systems can be purchased as separately specified cable and equipment.

To derive the maximum benefits indicated previously from using optical fibre systems in the main network, such systems must be available for use as an alternative to coaxial cable systems as early as possible in the modernisation programme. Thus, current plans aim to order the first batch of standard 140 Mbit/s optical fibre systems for the main network in 1983 for operational use in 1984/85.

DIGITALISATION OF THE MAIN NETWORK

Introducing digital transmission systems into the network in an economic manner poses considerable problems, primarily because the established large FDM network, comprising about 1600 hypergroups, must be interfaced with a growing number of digital TDM systems. Initially, digital systems can only be exploited economically for circuits between the terminal nodes of the DLS and cannot be integrated to give the same degree of flexibility as can additional FDM systems.

Strategy studies for network modernisation established that the most attractive and economic solution is to minimise the amount of inter-working between analogue and digital plant by undertaking a rapid modernisation programme of the PSTN. This calls for a completely digital main transmission network by the early-1990s, and dramatically alters the earlier strategy which was based on using digital transmission systems to meet the growth only which would have led to a gradual increase in digital penetration reaching little more than 50% of the network by the year 2000. The rapid programme now being implemented requires a very large number of 140 Mbit/s systems to be ordered and brought into operational use to replace all analogue systems in less than 10 years.

Fig. 5 indicates the routes to be equipped with digital transmission in the early years of the programme. The planning and provision dates for these digital transmission systems also take account of the requirements for the X-Stream services.

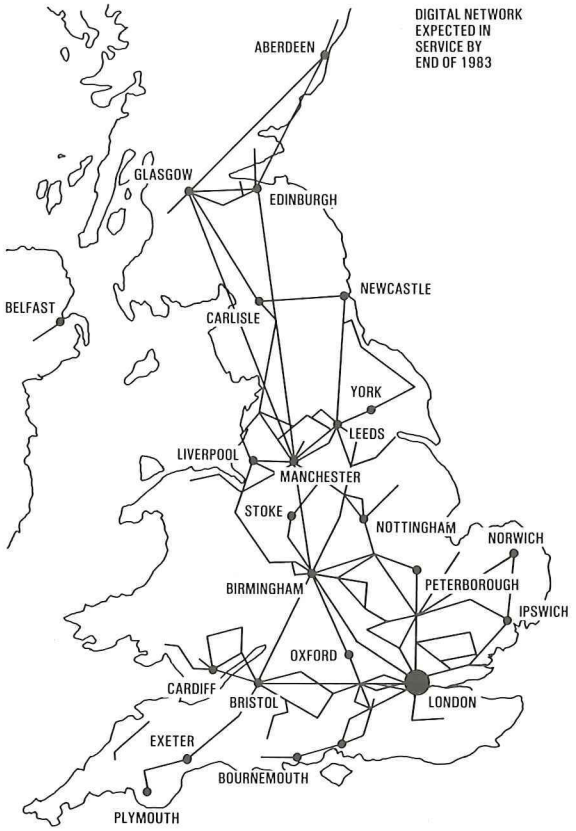


FIG. 5—Main network digital systems

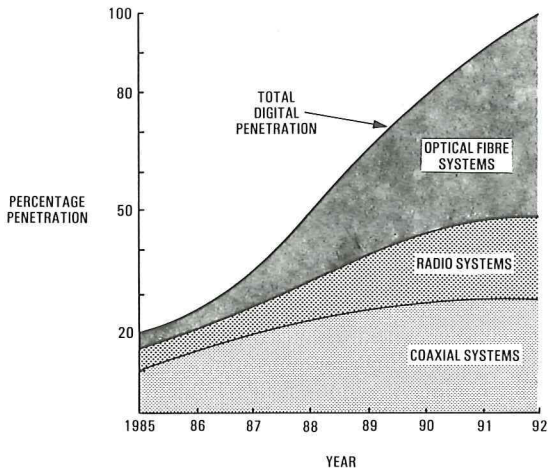


FIG. 6—Digital penetration of main network by 140 Mbit/s systems

The percentage penetration of 140 Mbit/s digital systems on the different types of transmission media to meet the main network programme is illustrated in Fig. 6. To achieve this rapid change-over of equipment, it will be necessary to take full advantage of technological advances. No new coaxial cable will be purchased after 1984 and it is expected that about half of the main network 140 Mbit/s systems will be routed over optical fibre cable by about 1990.

DIGITALISATION OF THE JUNCTION TRANSMISSION NETWORK

The introduction of digital transmission into the junction network began over 10 years ago with the installation of 24-channel PCM systems which operate at 1·536 Mbit/s on existing deloaded audio cables. More than 7000 systems have been installed, principally to increase the circuit capacity of existing junction cables. However, as the system makes use of a 7-bit quantisation law and line signalling structure which is not compatible with System X exchanges or 2 Mbit/s systems, it will not be used in the modernisation programme.

The 2·048 Mbit/s DLS will be fully exploited on existing types of audio cables as far as practicable.

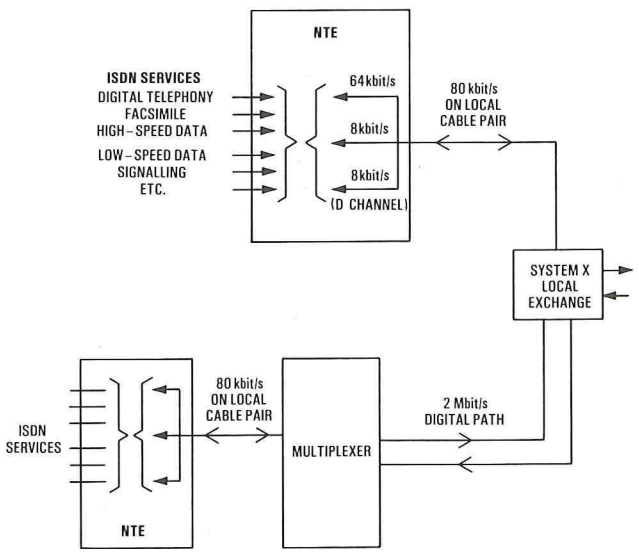
Where the use of new cables is preferred to intercepting existing large cables, a range of transverse screen cables have been introduced; these offer a higher degree of immunity to crosstalk and allow increased regenerator spacing. These systems will be used for traffic circuits between local exchanges as well as for customer circuits.

In addition, 8 Mbit/s and 34 Mbit/s systems on optical fibre cable are being used on a relatively small scale at present. As these systems offer the advantage of not requiring intermediate regenerators on most of the junction network routes, a very much larger scale of application for these systems can be foreseen as their cost decreases in the future.

EXTENDING DIGITAL TRANSMISSION INTO THE LOCAL NETWORK

The BT digital transmission network potentially offers customers 64 kbit/s circuits for low- and medium-speed data applications and 2 Mbit/s or 8 Mbit/s and above for higher speed uses. As the number of System X switching units linked by digital transmission rapidly increases it will become progressively possible to provide bothway 64 kbit/s switched transmission paths throughout the network between local digital exchanges. By providing digital access from the customers to System X local exchanges and adding certain non-voice service facilities the integrated services digital network (ISDN) will evolve.

Fig. 7 shows how the initial implementation of ISDN is envisaged based on the 80 kbit/s local access which will be used in the 1983 pilot scheme in London. In addition to the 64 kbit/s and 8 kbit/s digital traffic circuits, an 8 kbit/s message-based data channel for signalling and housekeeping, known as the *D channel*, between the customer and the local System X exchange is also provided.



NTE: Network terminating equipment
FIG. 7—ISDN concept

In order to reduce the number of 80 kbit/s circuits in the local networks and to serve customers on the fringe of the local distribution cables it is proposed to install remote multiplexers at intermediate sites, possibly housed in cross-connection cabinets, and extend the circuits over 2 Mbit/s paths. However, it is likely to be many years before national coverage of ISDN facilities can be achieved. The interim period will be served by the X-Stream services. In the case of KiloStream, access from the customer to the network node will be via a 4-wire circuit on standard unloaded local cable pairs using digital signals.

Techniques for adding bothway digital paths on the 2-wire telephone pair without causing disturbance to the existing telephone service are being investigated and include burst-mode operation, echo-cancellation, and frequency-division methods. Such systems, which provide additional capacity of at least one bothway 64 kbit/s channel, have the economic advantage of maximising the utilisation of existing local cables, but have restricted reach and capacity.

Digital radio systems operating in the 19 GHz band can provide a number of bothway channels and could be used for high-capacity customer connections for point-to-point and multipoint distribution applications. Assessment of the 19 GHz digital radio system has indicated that it could provide satisfactory service quickly and economically because the small size of antennas and equipment permits relatively easy mounting on buildings or poles; most applications would not need intermediate repeaters. Such systems are therefore considered ideal for high-capacity customer connections that need to be provided quickly, particularly where the connection is required for only a limited duration.

Optical fibre systems are likely to provide the best solution for more permanent long-term requirements for high capacity customer connections. These systems can be designed at any hierarchical digital rate from 2 to 140 Mbit/s, in almost all local network applications without the need for intermediate repeaters. Using the cheapest suitable fibre and simplifying terminal equipment design enables system costs to be minimised. A cost-reduced 2 Mbit/s systems is currently being evaluated.

Optical fibre systems also have great potential for the distribution of visual services in the local network. In this application, however, digital transmission may not be optimum and methods of avoiding expensive codec equipment are being studied; the most favoured method at the moment is pulse-frequency modulation. Optical fibre systems are featured in both the Visual Services Trial and the cable television system at Milton Keynes.

CONCLUSIONS

The decision to modernise the BT telecommunication network quickly has created the impetus to change from analogue to digital transmission at an unprecedented rate, posing some problem in planning for both growth and replacement of the analogue capacity.

A new main network is being built to meet both the present telephony and future digital data/information services. This network will make full use of the presently developed digital transmission systems, as well as higher capacity systems as they become available, particularly with the exploitation of optical fibre transmission.

The junction network is also being converted to digital operation making use of existing and new types of pair cables pending the availability of fully competitive optical fibre systems for general junction application. Methods of providing digital transmission in the local network are now available for customers to exploit the X-Stream services prior to the full availability of the ISDN to provide network coverage for enhanced data and visual services. Here there is plenty of room for innovation to maximise the use of existing types of local distribution cables, optical fibre cables and microwave radio in meeting the customers' futuristic requirements.

Book Review

Electronics 2 Checkbook. S. A. Knight. The Butterworth Group. 112pp. 156 ills. Hardback: £6·95; Paperback: £2·95.

Electrical Science 3 Checkbook. J. O. Bird, A. J. C. May, and J. R. Penketh. The Butterworth Group. viii + 128pp. 103 ills. Hardback: £6·95; Paperback: £3·50.

The Checkbook series is planned to cover all major syllabus areas of the Technician Education Council's (TEC's) and the Scottish Technical Education Council's (SCOTEC's) courses. The books are produced as handy, pocket-sized texts with the objective of summarising the main points of the subjects covered. Each chapter is concluded with a number of worked problems followed by a number of further problems divided into short-answer, multiple-choice and conventional-type questions, with answers given at the back of the book. The books, though small, are well produced and clearly illustrated.

Although it is not clearly stated, *Electronics 2 Checkbook* appears to cover the TEC Level II syllabus U76/010 which has now been dropped from the revised programmes for Electronics and Telecommunications. The book now covers parts of Electrical and Electronic Principles II (U81/747), Digital Techniques II (U81/750) and Electronics III (U81/743). The subjects covered are elementary theory of semiconductors, the p n junction diode, diode applications, transistors and their characteristics, small signal amplifiers, oscillators, the cathode-ray tube, logic symbolism and logic-gate elements.

Electrical Science 3 Checkbook is aimed at the mechanical, vehicle, or production-engineering technician and covers TEC Level III unit U75/062, which is still current. The topics covered are machines (DC only), alternating voltages and current, effects of inductance and capacitance in AC circuits, parallel AC circuits, 3-phase systems, transformers, electronic systems, basic digital circuits, feedback systems and practical feedback systems.

These books will no doubt prove to be very popular with students as valuable aids to revision, but they should not substitute, and are not intended to substitute, the fuller treatment given in larger textbooks. The *Electronics 2 Checkbook* is spoilt to a certain extent by a large number of errors, some of which will be confusing to the student. For example, on page 2 "band" should read "bond"; on page 3 a reference in paragraph 4 to the "positive pole" should be to the "negative pole"; on page 23, in the description of the operation of the full wave bridge rectifier shown in Fig. 5, the diode numbers are misquoted; on page 25 a reference to Fig. 3 should be to Fig. 8, and a voltage quoted as 2 V should be 2$\dot{V}$.

R. HARVEY

Electronic Exchange System TXE4A

Part 1—Background to the Development

G. R. LEGGETT†

UDC 621.395.345:621.395.65

The contract placed with Standard Telephones and Cables in 1971 for a production-engineered version of the TXE4 exchange system included a condition that further joint studies would be undertaken with British Telecom to identify the potential for reducing the capital cost of the system. Part 1 of this article describes the events leading up to the TXE4A development; Part 2, to be published later, will describe the TXE4A development, based on the TXE4 system architecture, which has reduced system costs and improved facilities.

INTRODUCTION

The decision in 1971 to replace the larger Strowger electromechanical local exchanges with the electronic exchange system known as *TXE4*[1,2] was based largely on the premise that there would be considerable potential for further development as more advanced technology became available.

Indeed, prior to the first TXE4 being brought into service (BIS) at Birmingham Rectory in 1976, a Cost Reduction Working Party set up jointly by Standard Telephone and Cables (STC) and British Telecom (BT) had successfully formulated development plans for the succeeding generation of equipment (see Fig. 1), and the development of the TXE4A exchange system had commenced with the prime aim of reducing system costs.

COST REDUCTION WORKING PARTY

This working party was established in 1971 with a membership of interested parties drawn from BT and STC's Electronic Switching Development Department.

Phase I of the study was concerned with investigating the design of the TXE4 exchange system to identify the most promising areas for further study and detailed cost appraisal. Study teams were formed with joint participation to investigate the following broad areas of work:

(*a*) electrical changes incorporating the use of integrated circuits, together with limited functional modifications;
(*b*) value analysis on equipment practice and manufacturing methods;
(*c*) state-of-the-art techniques such as the introduction of a range of large-scale integration (LSI) devices;
(*d*) operational and service changes associated with provisioning and dimensioning rules;
(*e*) major system reorganisation; and
(*f*) manufacturing savings concerned with variety control and a reduction of installation times.

Initial studies of these areas indicated that certain aspects of the system's design would require considerable development effort to yield significant cost savings; other areas promised considerable savings for a relatively low development effort. A report on this first phase of the cost-reduction study identified the items worthy of a more detailed analysis, and a second phase of the study was commenced.

Phase II of the study was therefore concerned with defining the detailed requirements of proposals outlined in the phase I study and preparing as far as possible block schematic diagrams of each functional subsystem to be redesigned. From these detailed proposals, more accurate costings which could be used as development target figures were made.

As with phase I, the studies were concentrated on 6 categories of change.

(*a*) Electrical changes.
(*b*) Physical changes.

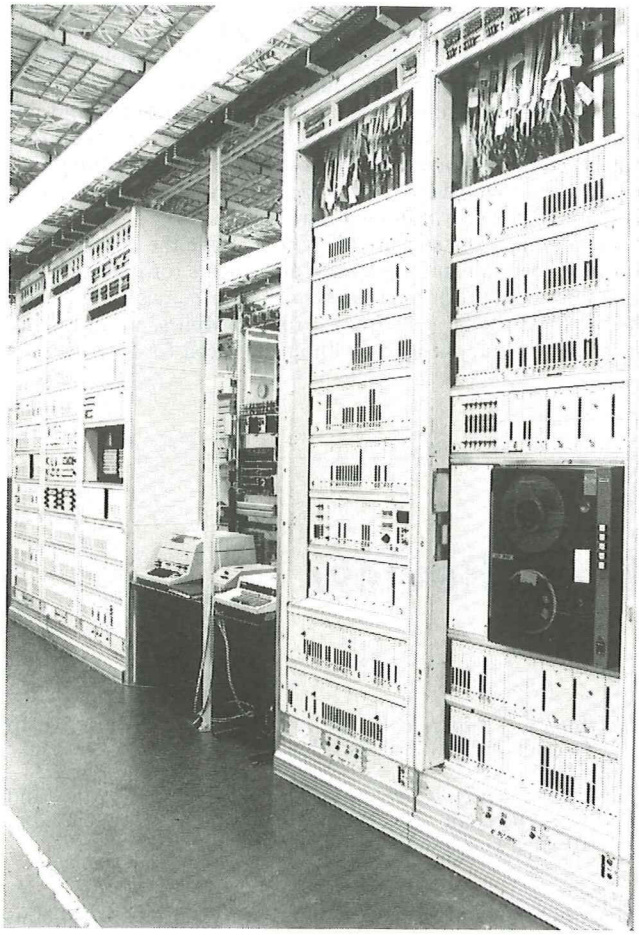


FIG. 1—TXE4A test bed (Model B) equipment. This equipment at Armour House, London, is used to provide test-bed facilities for future developments

† Exchange Systems Department, British Telecom Headquarters

(*c*) Changes to dimensioning rules.
(*d*) Changes to facilities.
(*e*) Potential savings in operational and service manpower.
(*f*) Use of LSI technology.

The most important of the features discussed during this phase are described below.

Electrical Changes

Studies on the feasibility of making electrical changes were concentrated on each exchange subsystem as follows.

Cyclic Store

The cyclic store of the TXE4 incorporates a threaded-wire store and a ferrite-core store for the state-of-line (SOL) logic. The use of these items resulted in a non-standard physical arrangement (hinged gates and short units) and a threaded store that was not electrically alterable.

The study proposed that the whole cyclic store should be radically redesigned to remove the above limitations. This involved the adoption of LSI shift-register stores to replace both the threaded-wire and ferrite-core stores. Such a realisation permitted electrically-alterable data storage and remote management of the exchange. Although this would be a radical change, it could be achieved in a manner which would allow interworking with the existing design of TXE4 equipment.

Main Control Unit and Register

The main control unit (MCU) for the TXE4 uses discrete components and a number of special ferrite-core stores associated with a miniature threaded-wire program store. The advances made in technology permitted a new design of MCU using integrated circuits, but providing an equivalent function to the existing TXE4 design.

The study proposed that the MCU should be redesigned to incorporate fully the latest technology so as to reduce the size and cost of the equipment. It was also considered important to make use of new technology to reduce the number of MCUs required in the larger exchanges to reduce capital costs further. To achieve this, proposals were made to add a second cyclic-store comparator and to off-load loop-disconnect pulse counting from the MCU software to hardware in the register. It was intended that a new design of exchange register should be developed incorporating pulse validation and single-digit storage using LSI devices. The proposed adoption of standard LSI memory devices in the MCU also removed the limitation of program size in the TXE4 design and made way for future enhancement of the system.

Supervisories

The TXE4 supervisory processing unit (SPU) uses ferrite stores with some integrated circuit logic. The cost reduction study proposed a new design based upon standard LSI memory devices which would dramatically reduce the size, and therefore the cost, of the SPU. Little change was proposed for the marker and interrogator areas of the system except to redesign them to make use of integrated circuits.

Highways

One of the major problems recognised by the Cost Reduction Working Party was that the highways of the TXE4 were severely limited in length and transmission speed. For cyclic store to MCU transmission, 300 pairs were required because parallel signalling for each 2-out-of-5 digit was used. The study proposed that binary signalling should be used throughout the cost-reduced design in a 4 bit binary + 1 bit parity form to enable the use of standard integrated transmitter and receiver devices. To achieve a major reduction in highway pairs on the cyclic store to MCU highways, it was suggested that development should be undertaken to establish the design requirements for a highway system operating well in excess of 1 Mbit/s compared with the 84 kbit/s of the existing design.

Pulse Generator

The pulse generator in the TXE4 provides a large number of pulse feeds for the exchange and requires a complete rack and sometimes an extension rack to mount all the equipment. The study proposed the use of integrated circuits in the pulse generator and a substantial reduction in the number of pulses distributed around the system. Such a design would be accommodated on a small part of a rack only. Areas of the exchange requiring further pulse phases would regenerate them locally.

Interworking

One of the terms of reference of the cost reduction studies was that the existing TXE4 exchanges should be capable of extension by using the cost-reduced equipment. Proposals were made to provide interworking equipment between the different designs of subsystems. It was recognised that the addition of such interworking equipment would incur a cost penalty on at least the initial extension of a TXE4 exchange with TXE4A equipment.

Physical Changes

The study group on the physical aspects of the design recommended a number of changes falling into 2 broad categories:

(*a*) changes to be implemented without substantial effort, and
(*b*) changes requiring detailed development.

Proposals in category (*a*) covered such items as the redesign of unit connectors, simplification of panels and components and the adoption of high-quality planar plated-through printed-wiring boards.

Category (*b*) items included the development of a new reed relay for the switch matrix and the adoption of alternative wiring methods to facilitate automatic wiring and testing.

Operational Changes

Planning criteria and dimensioning rules were carefully examined. Proposals were made to reduce the traffic margin on the A switch, to provide switching units partially equipped with link circuits where appropriate, and to reduce the minimum provision of MCUs from 3 to 2. Other possible changes such as modified marker sharing rules and changes to the ratio of bridge/through links were discussed, but these changes did not provide cost savings.

Facility Changes

Although the prime aim of the studies was to reduce the cost of the TXE4, it was considered prudent to examine the design carefully in the light of facility enhancements to ensure that such facilities would not be prohibited in the future.

The proposed design of the cyclic store would enable the subscriber information to be controlled electrically, and such an approach opened new horizons of remote management capability. Other areas of the exchange were closely examined for similar possibilities. To cater for facility enhancement, including remote management, it was proposed that both the MCU and SPU should be provided with an input/output port structure to which a local exchange management processor could be attached in the future.

LSI Technology

It was assumed throughout the cost-reduction studies that the majority of integrated circuit logic in the new design would be in standard transistor-transistor logic (TTL). However, various parts of the detailed design proposals involved the adoption of standard and custom LSI memory and logic devices. Indeed, the fulfilment of the predicted cost savings depended heavily on the availability of the right technology at the right price. During the time of the phase II studies, the predominant LSI technologies were p-channel metal gate and p-channel silicon gate. Devices required were read-only memories (ROMs), random-access memories (RAMs), shift registers and a custom-designed logic circuit for the exchange register. However, when the report of the phase II studies was presented, n-channel silicon gate technology was beginning to appear, but it had been realised that during the course of the development, a change in LSI technology might have to be made.

Outcome of Phase II Study

The phase II study resulted in detailed proposals for changes throughout the TXE4 system. Of these proposals, some were of marginal benefit to cost reduction, others had significant advantages and certain other proposals covered non-costed benefits such as facility enhancements. Groups of these proposals were brought together to form action packages for cost-reduction development. One package was identified as being the most acceptable option providing an optimised cost reduction against the degree of overall change required. The package of proposals restricted the redesign to the control area of the exchange and excluded a number of proposals mainly relating to physical changes which would have required a disproportionate amount of effort to the cost savings obtained.

The main proposals identified in the action package selected are summarised below. It must be emphasised that this was the basis for the post cost-reduction study work and it does not necessarily reflect the actual design as now developed.

General

(*a*) Replace discrete components with integrated circuits wherever possible.

(*b*) Develop all necessary interfaces to enable cost-reduced equipment to extend TXE4 design exchanges.

(*c*) Provide capabilities for future enhancement.

Cyclic Store

(*a*) Replace threaded-wire and ferrite-core stores by LSI shift registers to provide an electrically-alterable store.

(*b*) Provide necessary back-up storage for the volatile main store.

Main Control Unit

(*a*) Modify addressing and storage organisation from 2-out-of-5 to binary and parity.

(*b*) Add a second cyclic store comparator.

(*c*) Replace miniature threaded-wire and ferrite-core stores with standard LSI memories.

(*d*) Increase the number of registers processed.

Register

(*a*) Introduce pulse validation and digit storage using a custom LSI device.

Supervisory Processing Unit

(*a*) Replace ferrite-core store and SPU logic with LSI memories where appropriate.

Highways

(*a*) Adopt standard integrated circuit drivers and receivers and convert cyclic store to MCU highways from parallel to serial working.

Pulse Generator

(*a*) Develop a small compact pulse generator based on integrated circuits providing only a few system pulses.

DEFINITION PHASE

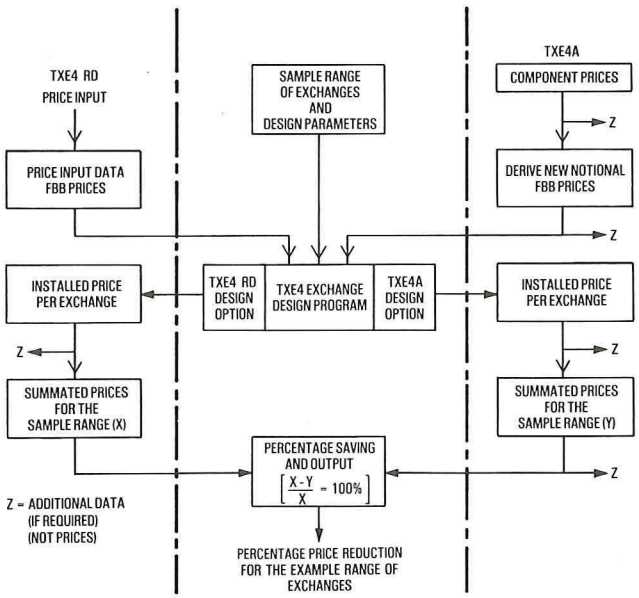
During the year that elapsed after the end of the phase II study, various facets of the proposals were seen to warrant further study. LSI technology had advanced and brought n-channel silicon gate devices onto the market, and electrically-programmable read-only memories (EPROMs) were beginning to be available. The definition phase of the cost-reduced TXE4 development involved not only the preparation of contract appendices, but also a re-appraisement of the best method of achieving the desired cost savings in each area of the system defined by the action package selected.

Along with the writing of definition papers, a formalised method of appraising the cost of the system was developed (see Fig. 2).

This cost monitoring activity was based upon principles used during the earlier cost-reduction studies. It involved the use of computer programs to obtain sets of cost estimates for an agreed sample range of exchanges, the first based on TXE4 equipment only and the second based on the replacement of TXE4 equipment with the new cost-reduced equipment where appropriate.

The topics covered during the definition phase are summarised below

(*a*) *Specification of functional circuit groups*
- (*i*) cyclic store and scanning,
- (*ii*) main control units and registers,
- (*iii*) call connection and supervision,
- (*iv*) pulse generator and common equipment, and
- (*v*) interworking.



FBB: Functional building block

FIG. 2—TXE4A system cost appraisement

(*b*) *Equipment practice.*
(*c*) *Power requirements and distribution.*
(*d*) *Documentation requirements.*
(*e*) *Electrical design standards.*
(*f*) *Software documentation standards.*
(*g*) *Rules for design cost estimates.*
(*h*) *Development approval procedures.*
(*i*) *Facilities, maintenance and system performance requirements.*
(*j*) *Dimensioning and testing of models.*

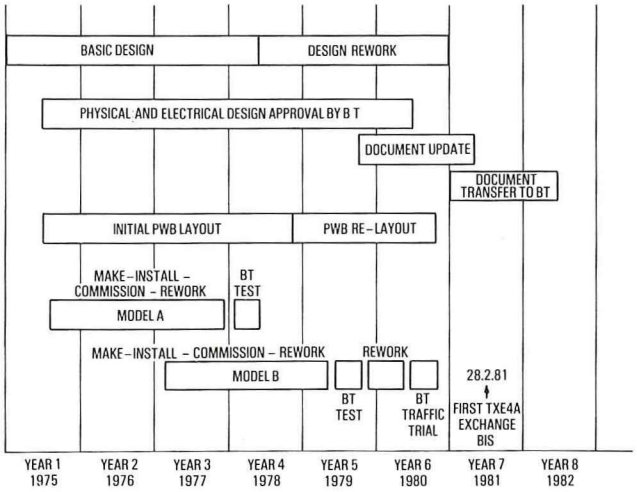
The specification for the functional circuit groups was divided into 2 parts. The first part was a detailed functional specification of the design and a list of the requirements that had to be met. This part was produced by BT and formally agreed by STC. The second part was STC's response to the detailed requirements in terms of design proposals down to functional circuit level. In this way, the original proposals of the Cost Reduction Working Party were embodied in a detailed specification of the proposed development.

Although during the early stages of the definition phase the new design was referred to as *cost reduced TXE4*, no firm title had been agreed. At one stage *TXE4 Mk II* was extensively used until it was decided to adopt the term *TXE4A* as the standard reference for the cost-reduced version of TXE4. In addition, the TXE4 system installed at Rectory Exchange, Birmingham, was being referred to as *TXE4 Rectory Design* and so the original TXE4 system design became identified as *TXE4 RD*.

DEVELOPMENT PHASE

The development contract, incorporating as appendices the detailed specifications produced during the definition phase, was let in April 1975. Key development activities are shown in Fig. 3. From these it can be seen that the BIS date for the first TXE4A exchange[3], at Belgrave in Leicester, was 28 February 1981. Of particular importance was the provision in the development contract for the production and commissioning of 2 TXE4A models. The first of these, Model A, was intended as a long-term model for STC's use and the second, Model B (see Fig. 1), as a BT model to provide test-bed facilities for future developments without the need to refer to STC's model. Model A incorporated the existing TXE4 RD model at STC's New Southgate factory and the first versions of the TXE4A equipment racks. An extensive BT series of tests, referred to as the *Model A quiet period*, was carried out during the first quarter of 1978 to validate the design.

Model B also incorporated both TXE4 RD and TXE4A design equipment, but, additionally, took into account some redesign of the equipment that had not been carried out on Model A.



PWB: Printed-wiring board

FIG. 3—TXE4A development activities

After a period of extensive testing (the Model B quiet period) Model B was transferred to BT premises in Armour House, London, during the first quarter of 1980.

The TXE4A development is now complete and has achieved the intended reduction in capital costs predicted by the Cost Reduction Working Parties.

Part 2 of this article will describe the detailed design of the developed system and the service and operational facets experienced to date.

ACKNOWLEDGEMENTS

The success of such a large-scale development can only be achieved by the abilities, dedication and close co-operation of the people involved. The author expresses his appreciation and thanks to past and present colleagues in BT and STC for their assistance during the development work and the preparation of this article.

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The Federation of Telecommunications Engineers of the European Community

R. E. FARR†

The Fédération des Ingénieurs des Télécommunications de la Communauté Européene (FITCE) originated from an idea of the French PTT engineers' association, whose representatives had preliminary discussions with their Belgian colleagues at Lille in April 1961. The discussions were extended to include West German representatives at a meeting in Paris a month later, at which the foundations of a federation to unite the associations of telecommunications engineers of the then 6 countries of the European Economic Community (EEC) were laid. The objectives were seen to be to improve the standing of telecommunications engineers throughout the EEC, to cultivate friendships across the frontiers to the benefit of the public telecommunications service and to suggest means of resolving mutual technical problems in a rational and uniform way.

Agreement was quickly reached between all 6 national associations and the FITCE was formally constituted as a chartered institution under Belgian law in October 1961. The founding members numbered 26 from Belgium, 20 from France, 5 from Italy, 2 from Luxembourg, 10 from the Netherlands and 13 from West Germany. The headquarters of the FITCE was permanently established in Brussels.

A set of Rules published in June 1962 was based on the concept that members admitted to the FITCE from different countries should join through their national association of telecommunications engineers and should, as far as possible, have a similar level of responsibility and common work interests. Full membership was restricted to those holding a responsible position in a public telecommunications service who had been educated to university level. It was agreed that a limited number of associate members should be accepted by direct entry from among engineers of equivalent status in the telecommunications manufacturing industry who did not belong to a participating national association.

The Rules state the following objects of the Federation.

(*a*) To further scientific development in the field of telecommunications.

(*b*) To develop cultural links and encourage friendly relationships between telecommunications engineers from the different member associations so that the engineers and their families can get to know each other better.

(*c*) To study, from every aspect, problems posed by the recruitment, training, work and careers of these engineers.

(*d*) To enable members to profit from the experience of others in all fields of telecommunications engineering and to investigate new ideas which will encourage the development of telecommunications in all the countries represented.

Membership had grown to 1112 by the end of the first year; 10 years later it stood at 2272. The Irish association was admitted to the FITCE in 1975 and the Spanish association was given special affiliated status in 1980 in anticipation of that country becoming a member of the EEC. By 1981 there were 3089 full members, comprising 180 from Belgium, 822 from France, 209 from Ireland, 511 from Italy, 11 from Luxembourg, 240 from the Netherlands and 1116 from West Germany. There were also 59 Spanish affiliated members and 277 associate members from industry.

Preliminary overtures to the then Institution of Post Office Electrical Engineers (IPOEE) (now the Institution of British Telecommunications Engineers (IBTE)) concerning British participation in the FITCE were made as long ago as 1971, but it was not until 1979 that a new initiative led to formal discussions. The Institution joined the FITCE as the national association for British membership of the FITCE in October 1981. Denmark was admitted at the same time. By July 1982 there were 70 British members.

The President of the FITCE is chosen from each member association in turn and serves for a maximum term of 2 years. The FITCE is administered by an Executive Committee which meets about 6 times a year and comprises the President, representatives from each national association (2 of whom serve as Vice-Presidents), the General Secretary and the Treasurer. Both of the last-named posts are honorary and are traditionally filled by senior Belgian members. The General Secretary is responsible to the Executive Committee for the day-to-day running of the organisation by a small permanent Belgian secretariat and the production of the quarterly *FITCE Review*.

An important task of the Executive Committee is to plan the Congress (Journées Européenes des Télécommunications (JET)) and General Assembly, which is held in a different European city each year; the first took place in Luxembourg in 1962. Since then, many of the principal cities in the EEC have been visited, and the FITCE returned to Luxembourg for the twentieth Congress in 1981. This year's event was held in Bordeaux from 6–11 September. Each Congress is devoted to a technical theme decided upon by the Executive Committee, with the presentation of papers followed by discussion so familiar to members of IBTE. Multi-lingual translation facilities enable all those present to participate. There is municipal, and sometimes national, government involvement in the opening and closing ceremonies, with media coverage, and some time is devoted to social events. Many of the 600 or so members who, on average, attend a Congress for all or part of the time are accompanied by wives/husbands and families, and special excursions are organised for those not attending the technical meetings. The General Assembly takes place on the final Saturday morning, when the Executive Committee reports to the membership on progress and the financial state of the FITCE, and delegates are asked to vote on policy and administrative matters. Naturally, events of this magnitude are beyond the financial means of either the FITCE or the host association and are therefore heavily dependent on the support of the local telecommunications administration and industry.

Another major task of the Executive Committee is to organise multi-national Study Commissions, which investigate and report on topics of mutual interest. Each Commission sits

† Mr. Farr is the Secretary of the Institution of British Telecommunications Engineers

for 2 years; the 5 in being when the IBTE joined the FITCE will soon complete their work and topics for new Commissions to study will be agreed next year. British participation in these will be invited. The Commissions meet during the annual Congresses and infrequently at other times, many of the exchanges of views being dealt with by correspondence. Recent topics have ranged from energy saving to the impact of telematics.

The FITCE does not attempt to emulate the activities of international standards organisations such as the International Telecommunications Union (ITU) or the Conference of European Posts and Telecommunications Administrations (CEPT). It exists primarily for the benefit of its members rather than the administrations they serve, with the aim of widening their knowledge of what is happening in telecommunications elsewhere in Europe. It is justly proud of its achievements over the 21 years of its existence, during which it has helped many telecommunications engineers throughout the EEC to get to know and understand each other better, in the spirit of the European ideal.

Book Review

Integrated Optics. IEE Conference Publication No. 201. Institution of Electrical Engineers. viii + 112pp. 137 ills. £22·00.

This book contains the texts of the 35 papers presented at the First European Conference on Integrated Optics held in London in September 1981. The topics covered included theoretical and experimental aspects of waveguide fabrication, the fabrication and use of electro-optic devices, lasers and other types of semiconductor devices, acoustic-optics and their role in signal processing, and fibre gyros and sensors.

In an invited paper entitled "Guided-wave devices for optical-fibre communications", R. C. Alferness of Bell Laboratories, USA, discussed the role that integrated optics could have in monomode optical-fibre systems and outlined how devices such as optical switches, modulators, wavelength filters etc. could be fabricated in electro-optic materials, such as $LiNbO_3$, and subsequently incorporated into practical fibre systems. While some of the papers presented concentrated on particular aspects of theory or technology, many authors discussed devices or structures which could be of particular interest for optical-fibre communications or signal processing applications.

Because of the specialised nature of some of the papers, these proceedings are likely to be of most interest to those working in the field of integrated optics or some closely related field. They are, however, also likely to be useful to those who have a more general interest in this rapidly expanding field and who wish to acquaint themselves with the areas currently being studied.

R. C. Booth

British Telecom Press Notice

ALL CHANGE IMPROVES PUBLIC PAYPHONES

British Telecom (BT) has introduced a new computer-controlled system, called *All Change*, to help quicken the clearing of coinboxes in London's public payphone kiosks. The system enables the coinboxes to be emptied as frequently as 6 times a day, 7 days a week. As well as monitoring London's 10 800 kiosks for jammed, dirty or damaged payphones and coinboxes, the All Change system counts the coins—which amount to about £381 000 a week—collected from them. It is expected that the number of out-of-order kiosks—estimated to be about 400 kiosks a day—will be reduced substantially.

The system has been installed in one of BT's West London buildings and will, after one year, save about £3 M, the sum BT pays the Post Office for collecting and counting the cash from the capital's coinboxes.

The pattern of collections of the All Change system is much more flexible than that employed before. The mini-computers controlling the system know the address of each kiosk, its telephone number, the type of housing and the payphone equipment inside, the type of cash container, who is responsible for cleaning it, and how often the cash is collected from it.

At collection time the BT collector marks a special card for each kiosk; he notes its condition and other information, and sends it with the sealed cash container to the All Change headquarters. The information on each kiosk is then read into a computer memory. The money is counted by associated machinery, bagged into denominations, transferred to a strong room and sent to a bank. The computers memory also notes how much cash each kiosk takes and how often its box fills up.

By 08.00 hours the next day, the All Change system, which has been working and counting at night, has sent a computerised analysis on local kiosks to terminals in each of London's 11 telephone areas. In addition, the system provides monthly, quarterly and annual analyses for management purposes, and for comparing payphone usage. The system can alter collection frequencies if a box is heavily used, and the telephone Areas can warn it of special events which might increase use, such as a major football match or a rail strike. The computer system deals with all kinds of coinboxes, including the new press-button electronic payphones, themselves computer-controlled, which are programmed to tell the system when their coinboxes are 75% full. The system is flexible and can be tailored to suit different needs in BT's Regions; it could be used by foreign telecommunications authorities.

The All Change system is a joint project between BT London and Chapman Cash Processing (CCP) of Telford, the company that designed the computer software and the unique coin-counting mechanism to BT's specifications. CCP designed, built and installed the system, including software origination, within 6 months of signing the contract.

Recent Major Events in the Evolution of British Telecom's Optical-Fibre Network

BRITISH TELECOM PRESS NOTICE

INTRODUCTION

This summer, British Telecom (BT) announced 2 more important milestones in the development of its optical-fibre telephone cable network: the inauguration of the London–Birmingham link, and the placement of a third stage of orders for optical-fibre cables and associated electronic equipment.

LONDON–BIRMINGHAM LINK

On 22 July, a new optical-fibre link—the world's longest—came into service between London and Birmingham, the busiest trunk route in Britain. BT also launched a new brand name for its optical-fibre activities—*Lightlines*.

The London–Birmingham link is 204 km long: 129 km longer than any previous BT optical-fibre link. Although longer links were known to be planned, it was, at the time, the longest link in service anywhere in the world. BT started laying the cable in October last year, and after only 9 months the cable began carrying calls between the country's 2 major business centres.

The cable was manufactured by BICC Telecommunication Cables Ltd., who also supervised its installation; the regenerators along the length of the cable and the terminal equipment at London and Birmingham were supplied by Plessey Telecommunications Ltd.

The link is a major technological achievement since it is the first in the UK to be operated at long wavelength. The transmission equipment uses high-radiance light-emitting diodes (LEDs) emitting at a wavelength of 1·3 μm, compared with 0·85–0·90 μm in earlier systems. The longer wavelength radiation has an attenuation of less than 1·5 dB/km, which allows the intermediate regenerators to be installed at intervals of up to 25% longer than on existing optical systems (at intervals of 10 km instead of 8 km). This means that there is a

British Telecom's Lightlines network—4000 fibre kilometres already installed, and a further 22 000 fibre kilometres currently on order.

Sir George Jefferson, Chairman of British Telecom, compares a specimen of optical-fibre cable with a high-capacity coaxial cable as he opens the London–Birmingham optical-fibre link.

fewer number of items requiring maintenance. (Earlier this year the longest optical-fibre transmission of over 102 km, without using regenerators, was announced†.)

The use of LEDs instead of lasers as light sources offers cost reductions, as well as improved reliability.

The cable contains 8 fibres, each 125 μm in diameter. Initially, 2 fibre pairs in the cable have been brought into service. These operate at 34 Mbit/s, each able to carry up to 480 telephone calls simultaneously. In 1983, the other 2 pairs will be used for 140 Mbit/s operation to give each a capacity of 1920 telephone calls.

ORDERS FOR AN EXTENSION TO THE OPTICAL-FIBRE NETWORK

The inauguration of the new link came just a few days after BT announced a major extension to its national optical-fibre cable network equivalent to more than half of the existing system network.

Comprising just over 1250 km of cables and more than 10 000 km of fibre, the orders are worth about £10·5 M and cover 35 separate routes. The orders for cables and associated equipment have been placed with Plessey Telecommunications Ltd., GEC Telecommunications Ltd., and STC plc. A large part of the optical-fibre production will be carried out at the factory to be built by Optical Fibres, Deeside, UK.

The 35 routes will be completed by April 1985; included among them is the world's longest operational monomode system, which will be installed on the 52 km Liverpool–Preston route. Monomode fibre technology reduces costs by enabling the regenerators to be spaced even further apart (at 30 km intervals instead of the normal 10 km or so). Britain's first monomode link (Luton–Milton Keynes) was announced in July 1981 and is due to go into service during 1984.

The orders augment the existing optical-fibre network already installed or on order, which amounts to nearly 16 000 km of fibre (2000 cable kilometres). These account for about 80 routes and will be completed by mid-1985.

The third stage network comprises mainly trunk systems operating at 140 Mbit/s. The longer routes (except for the Liverpool–Preston monomode system) will involve the use of dependent regenerators at intervals of about 10 km. Light sources will generally be lasers or LEDs and receivers photodiodes.

† British Telecom Sets New Optical-Fibre Record, *Br. Telecommun. Eng.*, Apr. 1982, **1**, p. 49

British Telecom's research team has developed an automatic jointing machine for joining the tiny optical fibres with the precision needed to ensure that virtually no light is lost at the joints, and yet rugged enough to operate perfectly under normal cable-laying conditions. The machine is also capable of jointing the new monomode fibres. The machine is shown being used in a van, on site, in an experimental optical-fibre-cable-laying exercise.

GROWTH OF THE OPTICAL-FIBRE NETWORK

These developments reinforce BT's commitment to the use of optical-fibre technology in the evolving digital network. BT is creating the world's most comprehensive optical-fibre network, and it is anticipated that by the end of the decade at least 100 000 km of fibre will have been installed, linking all major cities and accounting for half the trunk network. These are the latest events in a chronology which dates back from the mid-1960s:

1965 Major research activity began into the use of optical fibre in public communications networks.

1977 Europe's first public telephone calls sent over an optical-fibre link were made using BT's Martlesham–Ipswich experimental link.

1979 First-stage orders were placed for the world's most comprehensive optical network totalling 3600 km of fibre and associated transmission equipment.

1980 The first operational link went into service between Brownhills and Walsall in the West Midlands.

1981 Second-stage orders were placed for fibres and associated equipment to bring the total length of fibre installed or on order to 16 000 km, including the first order for a monomode system.

1982 The world's longest optical-fibre link to date, using the advanced technology of long wavelength operation, has been brought into service.
Also, third-stage orders have been placed to bring the total length of fibres installed or on order to 26 000 km.

Martlesham Medal for Optical-Fibre Pioneers

BRITISH TELECOM PRESS NOTICE

AWARDS

Two British Telecom (BT) scientists, who achieved the first vital breakthroughs in optical-fibre technology, have received the Martlesham Medal. Dr. George Newns and Dr. Keith Beales were key members of a small BT research team which, in the late-1960s and early-1970s, helped to steer Britain into a leading position in optical communications.

In particular, they took the double-crucible method of making fibre from a crude laboratory concept to a highly-successful production process, which has been licensed to British, European and American companies and has a waiting list of applicants. The 2 scientists then went on to develop other techniques that, recently, have resulted in world records in optical-fibre systems being made.

The medals were presented at the Barbican Centre in London, on 26 July 1982, by Captain Robert Crippen, commander of the latest and next USA Space Shuttle, who was linked from Houston, Texas, by British Telecom International satellite circuits.

THE CONTRIBUTION TO OPTICAL-FIBRE TECHNOLOGY

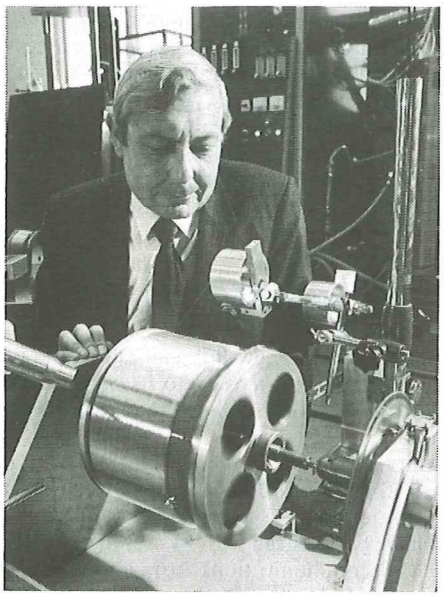
At the presentation ceremony, Sir George Jefferson, the Chairman of BT, said: "Optical communications is one of

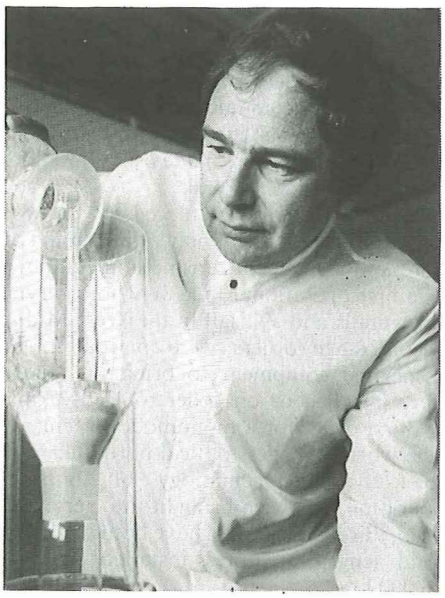
Dr. George Reginald Newns, 46, went to Wallasey Technical Grammar School and Liverpool University, where he gained a first class Batchelor of Science (BSc) degree in general science and then a BSc honours degree in physical and inorganic chemistry. He received his Doctor of Philosophy degree (PhD) for a thesis on *Glow Discharge Electrolysis*, and was subsequently appointed Research Fellow at Birmingham University.

In 1962, Dr. Newns joined the, then, British Post Office's Materials Division. After working on semiconductors, he was appointed, in 1968, to lead a research team investigating optical materials, and, later, fibre fabrication and evaluation for optical communications.

Dr. Newns has published over 50 scientific papers, a number of patents and, together with Dr. Beales and other colleagues, was awarded the 1978 Scientific Premium of the Institution of Electrical Engineers (IEE) for a paper on double-crucible fibre. In 1980, he was awarded the Potts Medal by the Chemical Society of Liverpool University. Since 1979, Dr. Newns has headed the Europe and Africa divisions of British Telconsult.

He is married, has one son, and lives at Hintlesham, Suffolk. His hobbies include sailing and yacht racing.





Dr. Keith John Beales, 42, attended the City of Norwich Grammar School where he won an Open Scholarship to Nottingham University. He obtained a BSc honours degree in Chemistry and then a PhD in Physical Chemistry with a thesis entitled *Organic Semiconductors* and was awarded a Post Doctoral Fellowship.

He joined the research department of the, then, British Post Office in 1966. During his years with the research laboratories he has been involved in work on materials aspects of silicon device technology as well as developing materials and techniques suitable for the production of optical-fibre.

Since 1979, he has led the research and development work on optical fibres including double-crucible technology, monomode fibre development and fibre strength and reliability. Dr. Beales has published over 50 science and conference papers and filed 15 patents. He is married, has one son, and lives in Ipswich.

those rare technologies where Britain not only led the world at the development stage, but is also out there in front in applying and exploiting the benefits.

"When it was first suggested, back in 1966, that light pulses transmitted through tiny strands of glass might be used for communications, it was BT researchers who first took up the challenge and began devoting time and resources to the enormous problems of translating theory into practice.

"Today, BT is breaking world records with performances which were undreamed of in those pioneering days. BT is building Europe's most extensive optical-fibre network—around 10 000 km of fibres will shortly be in daily use.

"By the end of the decade all of Britain's major cities will be linked by BT's Lightlines†.

"This rapid build-up of our network is also giving British manufacturers a splendid opportunity to forge a world lead in one of the most exciting technologies of the decade."

The Martlesham Medal winners were first off the mark in finding ways of reducing the deterioration of light signals transmitted through fibre. This deterioration is caused by several factors: the intrinsic property of the fibre, impurities in the materials used and the scattering effect of light. A number of patents have been secured as a result of this work. In those early days, the researchers had to produce a glass that was at the very least 1000 times purer than any in existence. Today, the purity of the glass used is such that if the oceans were made from it one would be able to see the sea bed.

The development of the double-crucible fibre production process, by Dr. Newns and Dr. Beales, was a major world breakthrough. Many attempts by others, including the Americans, Japanese and French, failed where the BT scientists succeeded. The process enabled BT to start a major programme of testing working systems in the field, and, by 1980, BT's customers became the first in Europe to make telephone calls over optical fibres. The double-crucible technique is, to this day, potentially the cheapest way of producing certain kinds of fibre, particularly multimode fibres, which have a relatively large central light-carrying core. Multimode fibres are ideal for use on short-distance systems such as local networks, data transfer within and between System X exchanges or instrumentation control. It is an extremely versatile process capable of producing most kinds of fibre.

Optical-Fibre Processes

In the double-crucible process, the 2 types of glass used, one for the core of the fibre and the other for the cladding, are fed into concentric platinum crucibles, one inside the other—the inner crucible containing the core glass. Each crucible has a tiny nozzle in the base. The fibre is pulled through the bottom nozzle of the outer crucible in a way that prevents the different glass melts from mixing together. The fibre is then coated with a resin for protection and wound onto a reel.

For the next generation of high-performance monomode fibres used for long-distance and underwater routes, BT researchers developed another production process, known as chemical vapour deposition. The glass for the fibre is made by reacting gases at temperatures of up to 2000°C on the inside of a hollow silica tube. The tube is then collapsed under intense heat to form a solid rod, of about 2 cm in diameter, which already has the structure of the finished fibre. The rod is then fed into a furnace and pulled into a fibre.

† *Lightlines* is the new name given to BT's optical-fibre activities

The Martlesham Medal

THE MARTLESHAM MEDAL

The Martlesham Medal gives recognition to members of BT, past or present, who have made an outstanding personal contribution to science or technology with a particular relevance to telecommunications. It takes its name from BT's research laboratories at Martlesham Heath, near Ipswich.

A particular discovery, contribution to knowledge or innovation is sought by the awarding panel. The candidates' contributions are judged by international standards for their value in enhancing national prestige and potential for increasing the prosperity of Britain, either by benefits to customers or significance to industry.

The first recipient of the Martlesham Medal, in 1980, was Dr. Tommy Flowers, who invented Britain's, and possibly the world's, first computer, and is the acknowledged father of electronic switching. During the Second World War, Dr. Flowers played a brilliant part with his invention of the COLOSSUS machine, so named because of its enormous size, which played a major role in breaking German High Command codes. The basis of the machine set Dr. Flowers on the road to developing techniques for electronic switching, so vital to modern telecommunications.

The second recipient of the Martlesham Medal, in 1981, was Mr. Dennis Baker, who pioneered the introduction of the world's first silicon chip transistors used in amplifiers for submarine cables and who led the team which coined the term "microprocessor". At a time when other organisations were using germanium transistors for amplifiers in submarine cables, Mr. Baker was the first to believe that the new silicon devices could give higher and more consistent reliability. He developed testing methods to achieve completely acceptable transistors which could work in cables at a depth of 4·8 km. The last 2 generations of his transistors have been working without failure fot the past 10 years.

Installing Mobile Telephone Exchanges at Bruton

R. S. WILSON†

The Strowger unit automatic exchange (UAX) No. 14 at Bruton, near Bristol, is being replaced with a TXE2 electronic telephone exchange. Unfortunately, there was insufficient space in the exchange building to provide turn-round facilities during the change-over from the old to the new exchange. The normal procedure in such a case is to provide mobile telephone exchanges (*mobiles*), which are usually placed on the existing site and give the customers service while the equipment is being changed. At the Bruton exchange this proved to be impracticable since there was insufficient space to accommodate mobiles, and so a search was made for an alternative site to locate them. Ideally, the site had to be close at hand and level, and have good access and mains services.

The town of Bruton is very congested and there was very little choice of site, but, finally, the garden of the primary school was obtained on a short lease. The site has presented the Building Liaision Group with a few interesting problems.

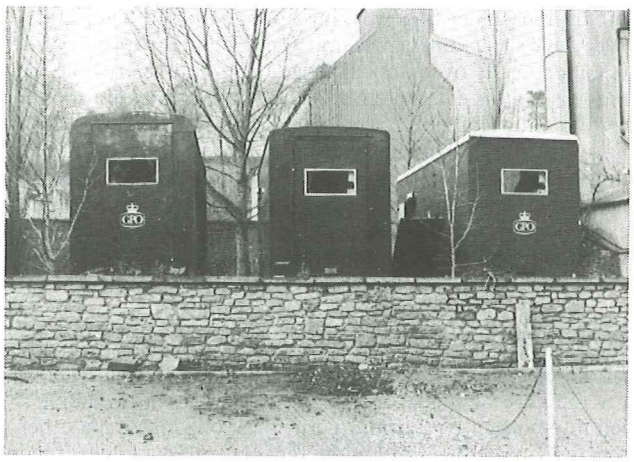
One of the most important clauses in the lease stipulated that the site will have to be restored to its original condition when it is vacated in about 3 years time. Normally, mobiles are sited either on concrete slabs (or strips) or on a base of chippings, and manhandled from the low loader which delivers them to the site. However, it soon became apparent that alternative methods would have to be found for providing the hardstanding and, as there is a 1 m high stone wall across most of the front of the site, for moving the mobiles onto the site.

For the hardstanding it was decided to use Somerfeld Flexboards, which are fabricated from hardwood boards bound together with steel strips and have facilities for spiking them to the earth. These are generally used by the construction industry for temporary roads, and are frequently used at building sites, showgrounds etc. The boards were delivered to site and laid out in exactly the right positions and levelled a few days prior to the arrival of the mobiles.

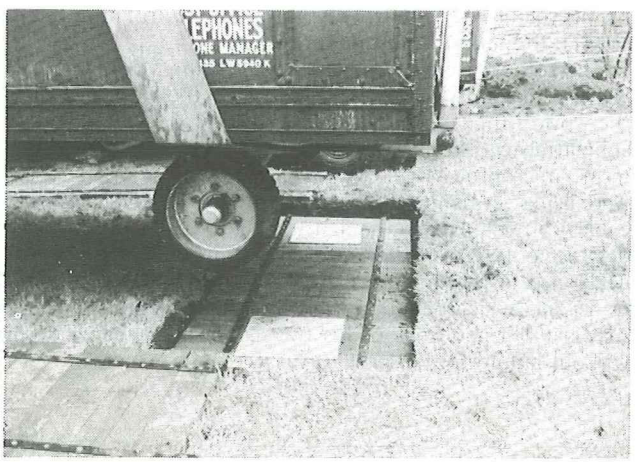
The mobiles were lifted from the low loaders onto the site by using a crane hired from a local contractor. This was done for 2 reasons: firstly, it would have been very expensive to demolish the wall and subsequently rebuild it and, secondly, 2 trees which had been denoted by one of the school's governors were obstructing the way and under no circumstances were they to be damaged. Spreaders were used with the lifting tackle used to lift the mobiles so that the sides of the mobiles were not crushed. Only one man was required at each corner to steady the mobile and guide it into position.

The whole operation was a complete success and was far easier, quicker and cheaper than some similar operations on less involved sites with more conventional arrangements. It is anticipated that the same procedure will be used to recover the mobiles, and that the boards will be of further use in other similar circumstances. The garden will be easily restored to its original condition after the boards have been lifted.

Mobile telephone exchange being lifted over the stone wall



Three mobile exchanges installed on site



Boards, in position

† Bristol Telephone Area

Institution of British Telecommunications Engineers

(formerly Institution of Post Office Electrical Engineers)

General Secretary: Mr. R. E. Farr, BTHQ/TE/SES5.3, Room 458, 207 Old Street, London EC1V 9PS; Telephone 01–739 3464, Extn. 7223

(Membership and other local enquiries should be directed to the appropriate Local-Centre Secretary as listed on page 184 of this issue)

AMENDMENTS TO THE RULES OF THE INSTITUTION

The result of the ballot on a proposed change to Rule 33, which closed on 30 June 1982, was as follows:

To leave Rule 33 unchanged	854
To amend Rule 33 as proposed by Council	3193
Spoiled papers	2
Total	4049

Of the total Membership, 30·5% took part in the ballot (this represents 31·5% of those eligible to vote).

In consequence, Rule 33 is amended to read, in full, as follows:

"33. Power to alter, add to or cancel any of the Rules of the Institution shall be vested in the Council, subject to the following limitations. Any proposal of the Council in this respect shall, except where the Chairman of Council certifies that such change does not affect the intended operation of the Rules, be submitted to each Corporate Member through the Honorary Local Secretaries and shall become operative unless, before the last day of the month following the month of issue, not fewer than 2% of the Corporate Membership as published in the last Annual Report shall individually or collectively demand that the members' decision be determined by a ballot of all the Corporate Members. If a ballot should negate the Council's proposals no further action shall be taken during the year.

If the next year's Council so desires, the proposals in the same or modified form may again be submitted to a ballot of all the members and the resulting decision shall be final for that year."

The above Rule became effective on 1 October 1982.

Members may like to note that a typed reference copy of the Rules of the Institution, updated to include all changes introduced up to 1 July 1982, is now held by each member of Council and by each Local-Centre Secretary. These copies will be updated at the end of 1982 to include the change to Rule 33 above and any subsequently agreed changes. A full reprint of the Rules on a per-member basis will be arranged when processing of the remaining changes under consideration has been completed, probably late in 1983.

CONSTITUTION OF THE COUNCIL FOR 1982–83

Chairman	Mr. D. Wray, Director of Business Planning and Strategy, BTHQ.
Vice-Chairmen	Mr. A. B. Wherry, Chairman of BTNW.
	Mr. D. V. Davey, Chairman of NE Postal Board.

Elected Members (Rule 18 defines Group representation):

Mr. I. G. White, HETA1, BTHQ, Honorary Treasurer.
Mr. D. A. Spurgin, HETA5, BTHQ, representing Group 1.
Mr. R. E. Burt, Service Controller, BTSW, representing Group 2.
Mr. R. D. Edwards, HG, BTHQ/T8.2.3, representing Group 3.
Mr. F. V. Spicer, HD, BT London City Area, representing Group 4.
Mr. B. H. House, HD, BT Brighton Area, representing Group 5.
Mr. P. Walling, EE, BTHQ/TSP3.1.1, representing Group 6.
Mr. E. Marmion, EE, LPR/HQ/ET1, representing Group 7.
Mr. K. Coxey, EE, BTNW/HQ/F221, representing Group 8.
Mr. T. K. Ray, AEE, BTHQ/TSP3.1.2, representing Group 9.
Mr. D. Mallows, AEE, BTL/HQ/P442B, representing Group 10.
Mr. R. C. Taylor, AEE, BTNW/HQ/Plg 1121, representing Group 11.
Mr. D. V. Gasson, Inspector, BT London South Area, representing Group 12.
Mr. N. R. Paul, Inspector, BT Manchester South Area, representing Group 13.
Mr. M. E. Webb, Senior Draughtsman, BTHQ/T10.1.1.2, representing Group 14.
Mr. C. G. Suett, Senior Draughtsman, BTE/HQ/ETC, representing Group 15.
Mr. L. Thomas, TTS, BTWM/HQ/PW3.4.5.2, representing Group 16.

Under Rule 25, the seats for Honorary Treasurer and Groups 2, 9, 10 and 11 became vacant this year. Messrs. White (Honorary Treasurer), Ray (Group 9) and Mallows (Group 10) were elected by virtue of being nominated unopposed. The seats for Groups 2 and 11 were contested, the unsuccessful candidates in descending order of votes cast being as follows:

Group 2	Messrs. A. Ness, E. Fowler and S. N. Godfrey.
Group 11	Messrs. D. W. Sharman, D. A. Randles and P. M. Cholerton.

RETIRED MEMBER—ERRATUM

The address of Mr. J. E. Adams was inadvertently given incorrectly in the April 1982 issue. It should read: "Joladima", Crockford Road, West Grimstead, Salisbury SP5 3RH.

INSTITUTION AWARDS

The Institution's Rules stipulate that medals shall be awarded on the basis of an adjudication of the printed papers, associated with lectures presented at Institution meetings, which are recommended by Local-Centre Committees for consideration. An experimental scheme is being introduced in co-operation with Local Centres which will, it is hoped, enable lectures given by members during the 1982/83 session to be judged for medal awards on presentation alone. If successful, the scheme will then be formally incorporated into the Rules.

MEMBERS ABOUT TO RETIRE

Members about to retire are reminded that they may secure life membership of the Institution at a once-and-for-all cost of £8·00. Retired members may enjoy all the facilities provided by the Institution, including a free copy of *British Telecommunications Engineering* posted to their home address.

Enquiries should be directed to the appropriate Local-Centre Secretary; members living in, or moving to, an area served by a different Centre from that to which they currently belong may find it more convenient to arrange a transfer to the new Centre's membership list before retirement in order to ensure advice on local activities.

R. E. FARR
Secretary

Local-Centre Secretaries

The following is a list of Local-Centre Secretaries, to whom enquiries about membership of the Institution should be addressed. It would be helpful if members would notify any change in their own address to the appropriate secretary.

Centre	*Local Secretary*	*Address and Telephone Number*
Birmingham	Mr. P. J. Thompson	British Telecom Midland HQ/PLT4.1, 245 Broad Street, Birmingham B1 2HQ 021–262 4287
Eastern (Bletchley)	Mr. D. R. Norman	British Telecom GMO/ED9.1, Telephone House, 25–27 St. John's Street, Bedford MK42 0BA (0234) 48299
Eastern (Colchester)	Mr. P. M. Cholerton	British Telecom East HQ/PLG2.1.4, St. Peter's House, St. Peter's Street, Colchester CO1 1ET (0206) 89547
East Midlands	Mr. D. W. Sharman	British Telecom GMO/ES3.3, 200 Charles Street, Leicester LE1 1BB (0533) 534409
London	Mr. L. J. Hobson	British Telecom HQ/ID/ICS7.2.2, Room 4024, Tenter House, 45 Moorfields, London EC2Y 9TH 01–432 1385
Martlesham	Mr. R. M. Brooks	British Telecom Research Laboratories, R9.2.4, Martlesham Heath, Ipswich IP5 7RE (0473) 643378
North Eastern	Mr. R. S. Kirby	British Telecom North East HQ/S3.1.2.4, 36 Park Row, Leeds LS1 1EA (0532) 467362
Northern	Mr. L. G. P. Farmer	British Telecom GMO/CI28, Swan House, Pilgrim Street, Newcastle-upon-Tyne NE1 1BA (0632) 327212
Northern Ireland	Mr. W. H. Tolerton	British Telecom GMO/EC1, Dial House, 3 Upper Queen Street, Belfast BT1 6LS (0232) 42444
North Western (Manchester and Liverpool)	Mr. W. Edwards	British Telecom North West HQ/F2.3, Telecommunications House, 91 London Road, Manchester M60 1HQ 061–863 7778
North Western (Preston)	Mr. R. L. Osborn	British Telecom GMO/PS, Telephone House, Fenton Street, Lancaster LA1 1BA (0524) 88400
Scotland East	Mr. J. C. C. Hunter	British Telecom Scotland HQ/P1.3.1, Canning House, 19 Canning Street, Edinburgh EH3 8TH 031–222 2396
Scotland West	Mr. G. A. Dobbie	British Telecom GMO/EX17, Marland House, 40 George Street, Glasgow G1 1BA 041–220 2365
South Eastern	Mr. O. V. Perry	British Telecom South East HQ/PE4, 52 Churchill Square, Brighton BN1 2ER (0273) 201733
South Western	Mr. D. P. Cosh	British Telecom South West HQ/Sv2.3.1, Mercury House, Bond Street, Bristol BS1 3TD (0272) 295578
Stone/Stoke	Mr. J. Coulson	British Telecom Technical College, IT7.3.4A, Stone ST15 0NQ (0785) 762351
Wales and the Marches	Mr. D. A. Randles	British Telecom Wales and the Marches HQ/PW3.1.2.2, 25 Pendwyallt Road, Cardiff CF4 7YR (0222) 391370

Forthcoming Conferences

Further details can be obtained from the conference department of the organising body.

FORUM 83 Secretariat, International Telecommunications Union, CH-1211 Genève 20, Switzerland.
Telephone: 441–22–995190

Fourth World Telecommunications Forum, Part 2, Technical Symposium
29 October–1 November 1983
New Exhibition and Conference Centre, Geneva
Papers: Summaries by 1 November 1982

Institution of Electrical Engineers, Savoy Place, London WC2R 0BL. Telephone: 01–240 1871

Third International Conference on Electrical Safety in Hazardous Environments
1–3 December 1982
Institution of Electrical Engineers

Second International Network Planning Symposium (Networks '83)
21–25 March 1983
University of Sussex

Third International Conference on Antennas and Propagation (ICAP 83)
12–15 April 1983
University of East Anglia

Third International Conference on Satellite Systems for Mobile Communications and Navigation
7–9 June 1983
Institution of Electrical Engineers

Fifth International Conference on Software Engineering for Telecommunications Switching Systems
4–8 July 1983
Lund, Southern Sweden

Second International Conference on Radio Spectrum Conservation Techniques
6–8 September 1983
University of Birmingham
Papers: Synopses by 15 October 1982

Third International Conference on Reliability of Power Supply Systems
26–28 September 1983
Institution of Electrical Engineers
Papers: Synopses by 1 October 1982

Notes and Comments

CONTRIBUTIONS TO THE JOURNAL

Contributions to *British Telecommunications Engineering* are always welcome. In particular, the Board of Editors would like to reaffirm its desire to receive short articles, especially those from Regions and Areas, dealing with current topics related to telecommunications engineering, or of general interest to telecommunications engineers and managers.

In July 1977, a new style of presentation for contributions received from Areas and Regions was adopted. The general heading of "Regional Notes" was discarded and each individual contribution, along with its author's credit, was given greater prominence as an article in the *Journal*. Since then the objectives for instituting this change have been achieved: articles submitted by Regions and Areas have become an integral part of the *Journal*. Indeed, a number of contributions have been of sufficient length to be published as main articles.

However, although these contributions have continued to flow regularly into the editorial office, the editors still feel that many potential authors, for one reason or another, may still be inhibited from submitting copy to the *Journal*. Intending authors should not be held back from submitting articles because of ill-founded suppositions, such as lack of confidence in their command of the English language, their grade, or a feeling that an article on some day-to-day topic will be out of place among the more usual technically-based articles. On the contrary, the shorter Regional-type articles provide a perfect contrast to the more specialised articles and benefit the *Journal*'s balance of content.

There must be many telecommunications-related topics that would be of interest to the *Journal*'s readers that potential authors could explore—investigations, innovations and unusual projects. Back issues of the *Journal* should provide the inspiration for further ideas and topics. However, the editors recognise that imagination is an essential ingredient of authorship, and believe that it ought to be reflected in an author's choice of subject.

Anyone who feels that he or she would like to contribute a shorter-type article (or indeed a long article) should contact the Managing Editor, at the address below, in order to discuss whether a chosen subject is suitable for publication in the *Journal*. The editors will always be pleased to give advice and try to arrange for help with the preparation of an article, if this is needed.

GUIDANCE FOR AUTHORS

Some guiding notes are available to authors to help them prepare manuscripts of *Journal* articles in a way that will assist in securing uniformity of presentation, simplify the work of the *Journal*'s editors, printers and illustrators, and help ensure that authors' wishes are easily interpreted. Authors should note that the guiding notes have recently been rewritten to include a number of changes in the *Journal*'s editorial standards. Any author preparing an article is invited to write to the Managing Editor, at the address given below, to obtain a copy.

All contributions to the *Journal* must be typed, *with double spacing between lines*, on one side only of each sheet of paper.

As a guide, there are about 750 words to a page, allowing for illustrations, and the average length of an article is about 6 pages, although shorter articles are welcome. Contributions should preferably be illustrated by photographs, diagrams or sketches. Each circuit diagram or sketch should be drawn on a separate sheet of paper; neat sketches are all that is required. Photographs should be clear and sharply focused. Prints should preferably be glossy and should be unmounted, any notes or captions being written on a separate sheet of paper. Good colour prints and slides can be accepted for black-and-white reproduction. Negatives are not required.

It is important that approval for publication is given at organisational level 5 (that is, at General Manager/Regional Controller/BTHQ Head of Division level), and authors should seek approval, through supervising officers if appropriate, before submitting manuscripts.

Contributions should be sent to the Managing Editor, *British Telecommunications Engineering*, IDP 3.9, Room 704, Lutyens House, Finsbury Circus, London EC2M 7LY.

CORRESPONDENCE

The Board of Editors would like to publish correspondence on engineering, technical or other aspects of articles published in the *Journal* or on related topics.

Letters of sufficient interest will be published under Notes and Comments. Correspondents should note that, as it is necessary to send copy to the printer well before publication date, it will be possible to consider letters for publication in the January issue if they are received only by 8 November 1982, and for the April issue if they are received before 12 February 1983.

Letters intended for publication should be sent to the Managing Editor, *British Telecommunications Engineering*, IDP 3.9, Room 704, Lutyens House, Finsbury Circus, London EC2M 7LY.

IPOEE 75th ANNIVERSARY

Copies of the October 1981, IPOEE 75th Anniversary, special issue are still available; a summary of the contents of the issue and an order form are printed on page 186 of this issue of the *Journal*.

EDUCATIONAL PAPERS

The *Supplement* included with this issue of the *Journal* contains a reprint of one of the series of *Educational Pamphlets* published by British Telecom—*Field-Effect Transistors*. This is in addition to the normal sample question and answer papers for Technician Education Council (TEC) units and model answers for Scottish Technical Education Council (SCOTEC) examination papers.

The Board of Editors is considering publishing further similar educational-type papers and wishes to investigate the likely demand for such material. Further details about this proposed scheme are given in a foreword to the questionnaire printed on the middle 4 pages of the *Supplement*. Readers are invited to complete the questionnaire and return it to the Deputy Managing Editor at the address given.

Readers are also invited to express their views on the *Journal*'s coverage of TEC and SCOTEC subjects by completing the second part of the questionnaire.

SYSTEM X REPRINTS

The first 4000 copies of the book containing reprints of the System X articles from the *Journal* were sold very quickly. A further print was ordered and copies are now available; copies can be ordered by using the order form printed on page 187 of this issue of the *Journal*. Regrettably, it has been necessary to increase the price to British Telecom and Post Office staff to £1·50 a copy; the price to all others remains at £3·00 a copy (including postage and packaging).

MAC REPRINTS

The articles on *Measurement and Analysis Centres* (*MACs*) published in previous issues of this *Journal* have been combined, with minor amendments, and reprinted as a single booklet, and this is now freely available on request. To obtain copies of this booklet send a self-addressed A4-sized envelope to: BTHQ/ES5.3.2, Room 201, 203 High Holborn, London WC1V 7BU. The bottom left-hand corner of the envelope should be marked MAC ( ), and the number of copies required inserted inside the brackets; for example, MAC (2). Although no charge is being made for these reprints, non-employees of British Telecom are requested to stamp the self-addressed envelopes at the appropriate postal rate (net weight per copy is 125 g).

OCTOBER 1981 SPECIAL ISSUE

The October 1981 special issue contains articles on the following topics:

THE INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS
TELECOMMUNICATIONS AND SOCIETY
THE INLAND NETWORK
INTERNATIONAL SERVICES
SWITCHING AND SIGNALLING
MECHANICAL AND CIVIL ENGINEERING
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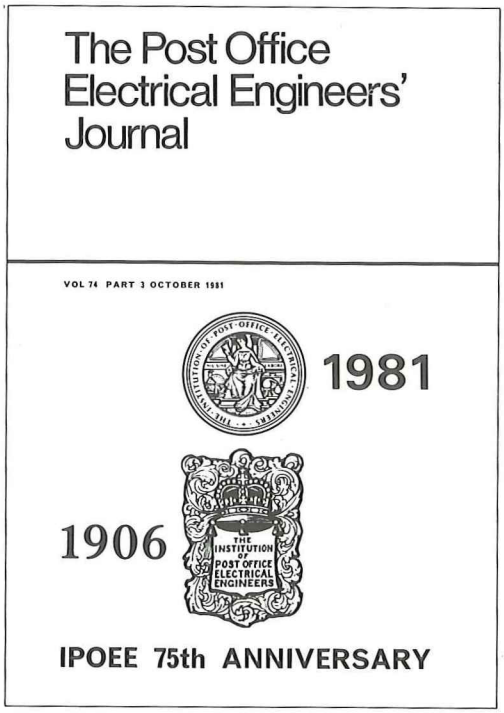

Copies of the issue are still available, price £1·30 each, including post and packaging (the cost to British Telecom and British Post Office staff is 48p).

If you wish to order copies, please complete the order form below and send it to the address shown. (Cheques and postal orders, payable to "*BTE Journal*", should be crossed "& Co." and enclosed with the order. Cash should not be sent through the post.

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The 26 articles on System X which appeared in the *Journal* between January 1979 and April 1981 have been reprinted as a single 160-page book. The articles in this book describe:

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The cost of this book is £3·00 including post and packaging (the cost to British Telecom (BT) and British Post Office (BPO) staff is £1·50).

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British Telecommunications Engineering

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The Board of Editors is not responsible for the statements made nor the opinions expressed in any of the articles or correspondence in this *Journal*, unless any such statement is made specifically by the Board.

Subscriptions and Back Numbers

The *Journal* is published quarterly in April, July, October and January, at 80p per copy (£1·30 per copy including postage and packaging); annual subscription: £5·20; Canada and the USA: $12·00.

The price to British Telecom and British Post Office staff is 48p per copy.

Back numbers will be supplied if available, price 80p (£1·30 including postage and packaging). At present, copies are available of all issues from April 1974 to date with the exception of the April and October 1975 and April and October 1976 issues.

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Readers can have their copies bound at a cost of £8·75, including return postage, by sending the complete set of parts, with a remittance, to Press Binders Ltd., 4 Iliffe Yard, London SE17 3QA.

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Communications

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All enquiries relating to advertisement space reservations should be addressed to Mr. N. G. Crump, The Advertisement Manager, *British Telecommunications Engineering Journal*, Room 616, 2–12 Gresham Street, London EC2V 7AG.

Model-Answer Books

Books of model answers to certain of the City and Guilds of London Institute examinations in telecommunications are published by the Board of Editors. Copies of the syllabi and question papers are not sold by *British Telecommunications Engineering Journal*, but may be purchased from the Sales Department, City and Guilds of London Institute, 76 Portland Place, London W1N 4AA.

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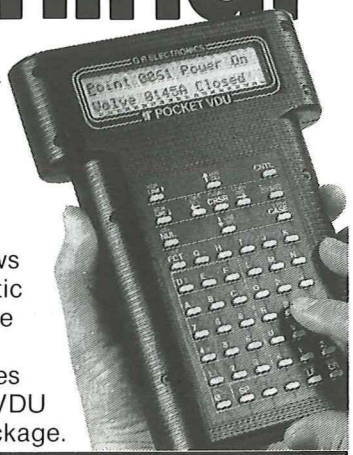

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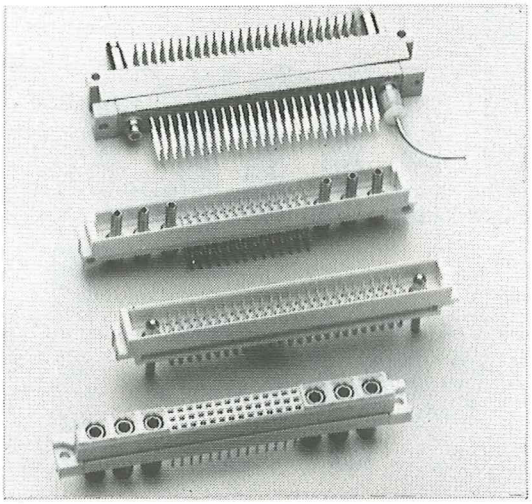

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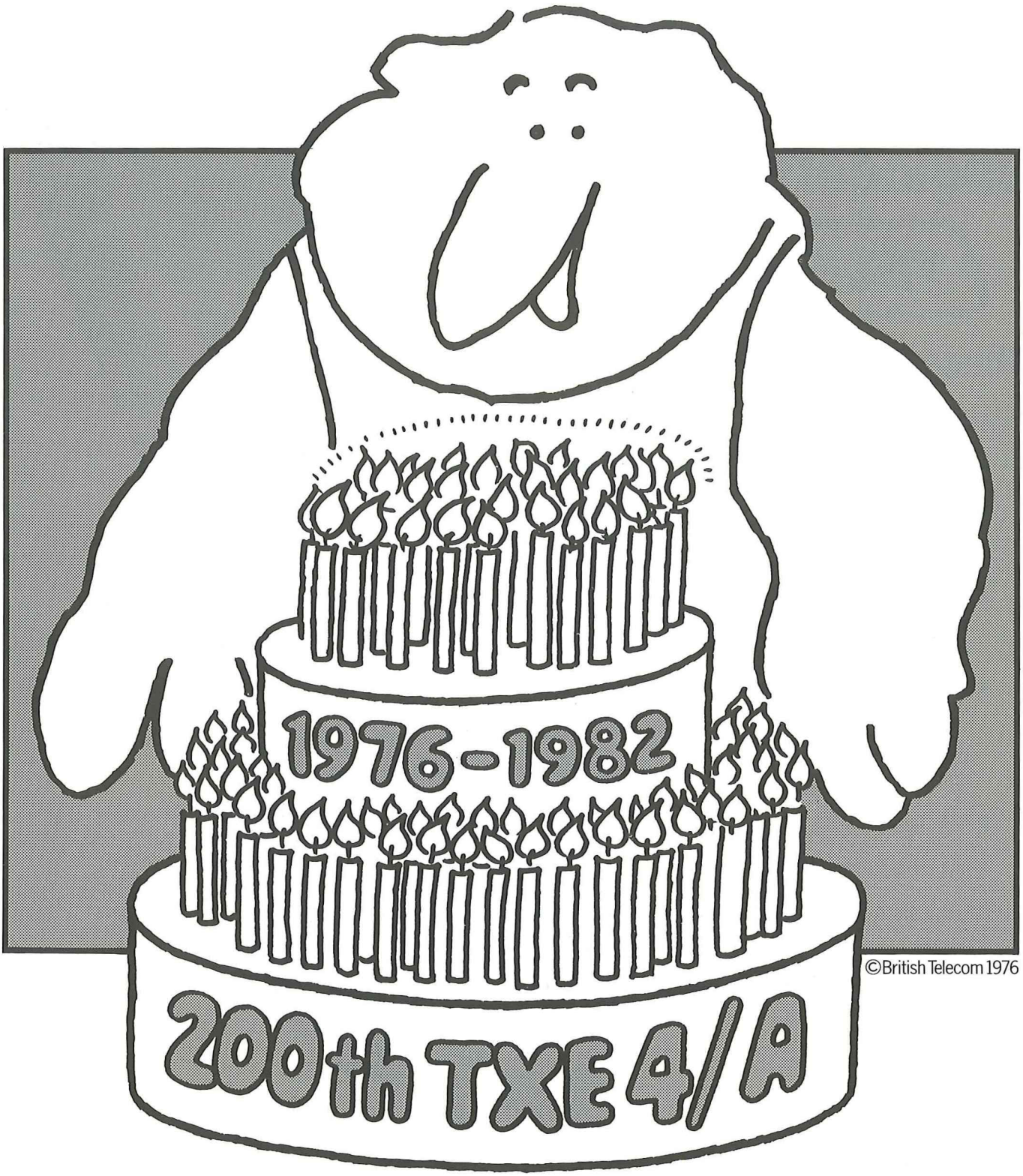

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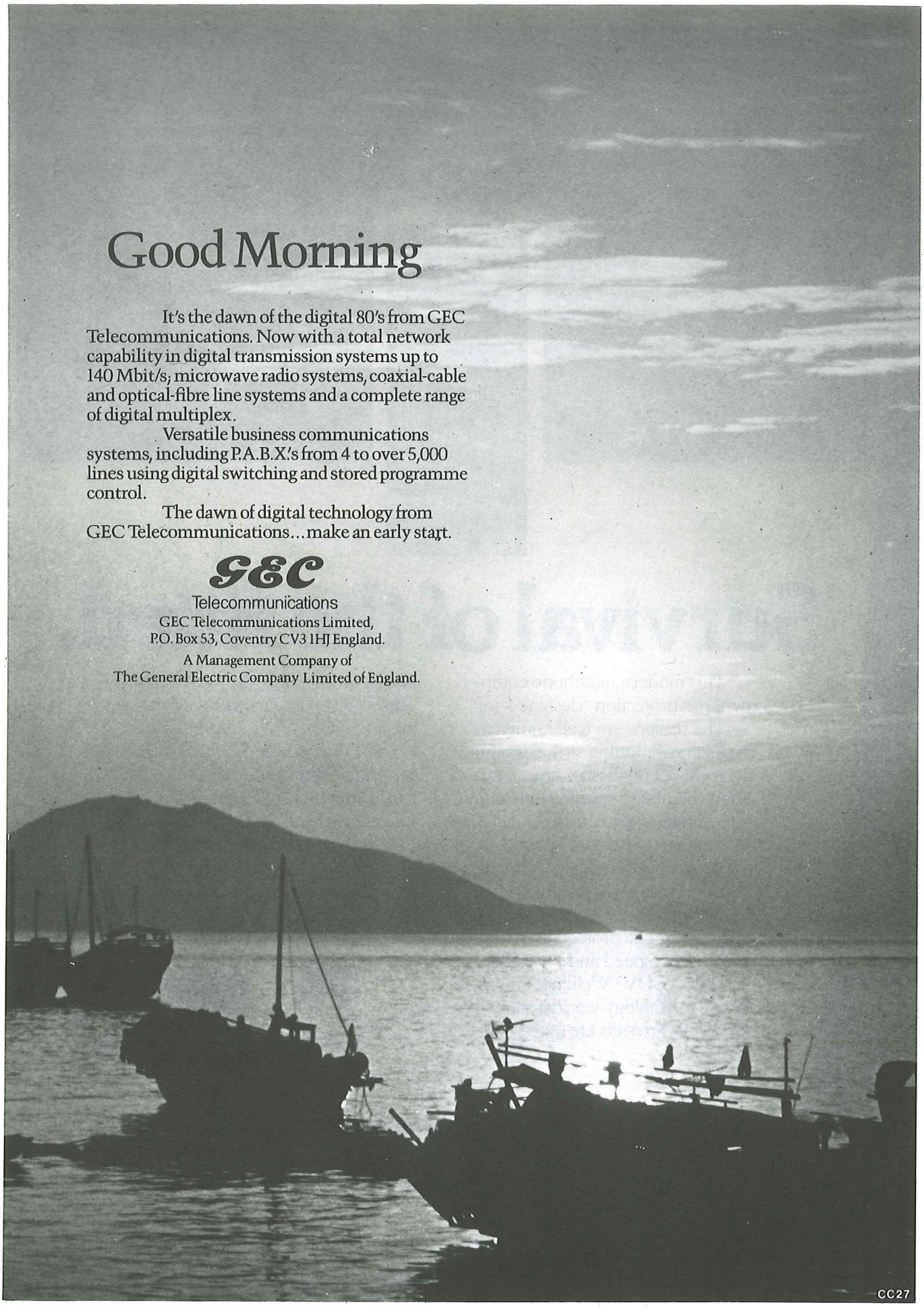
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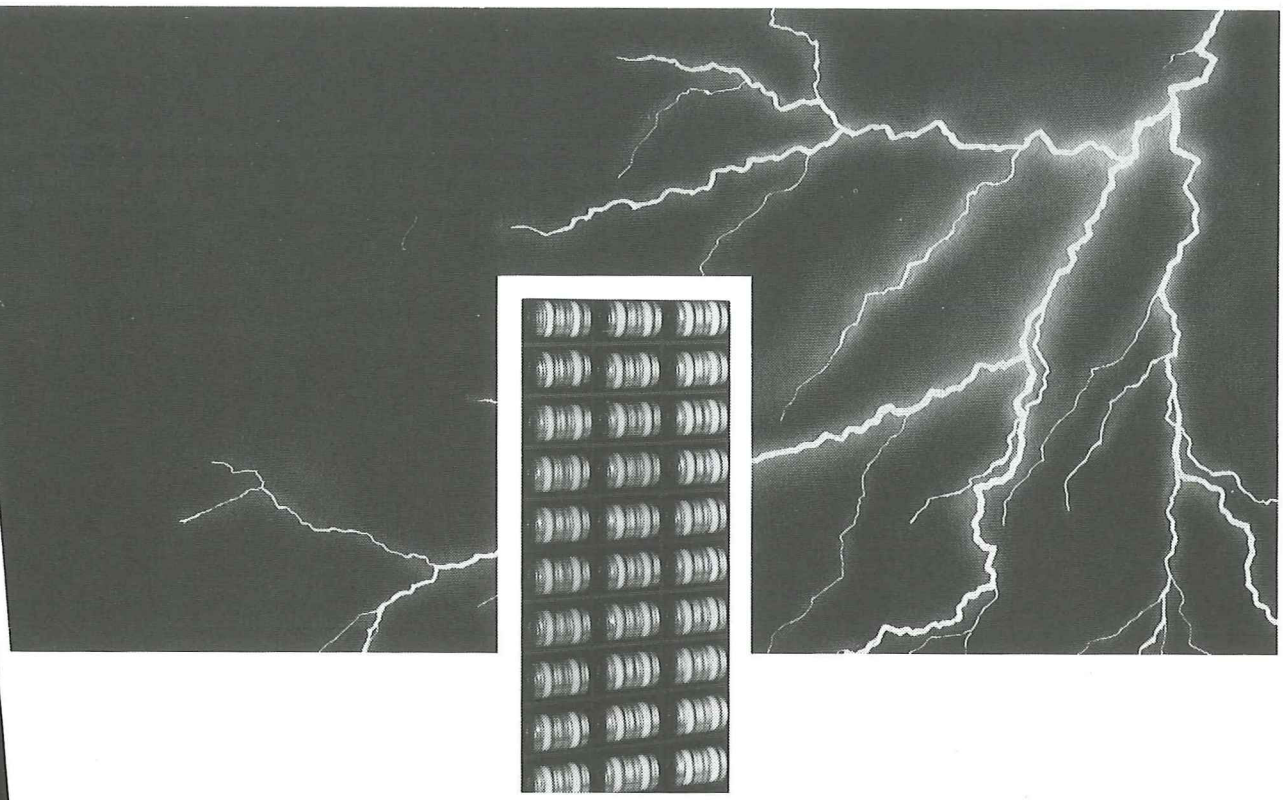

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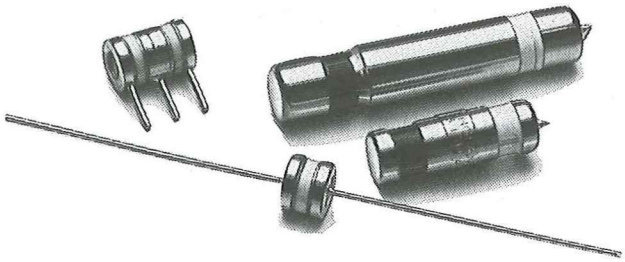

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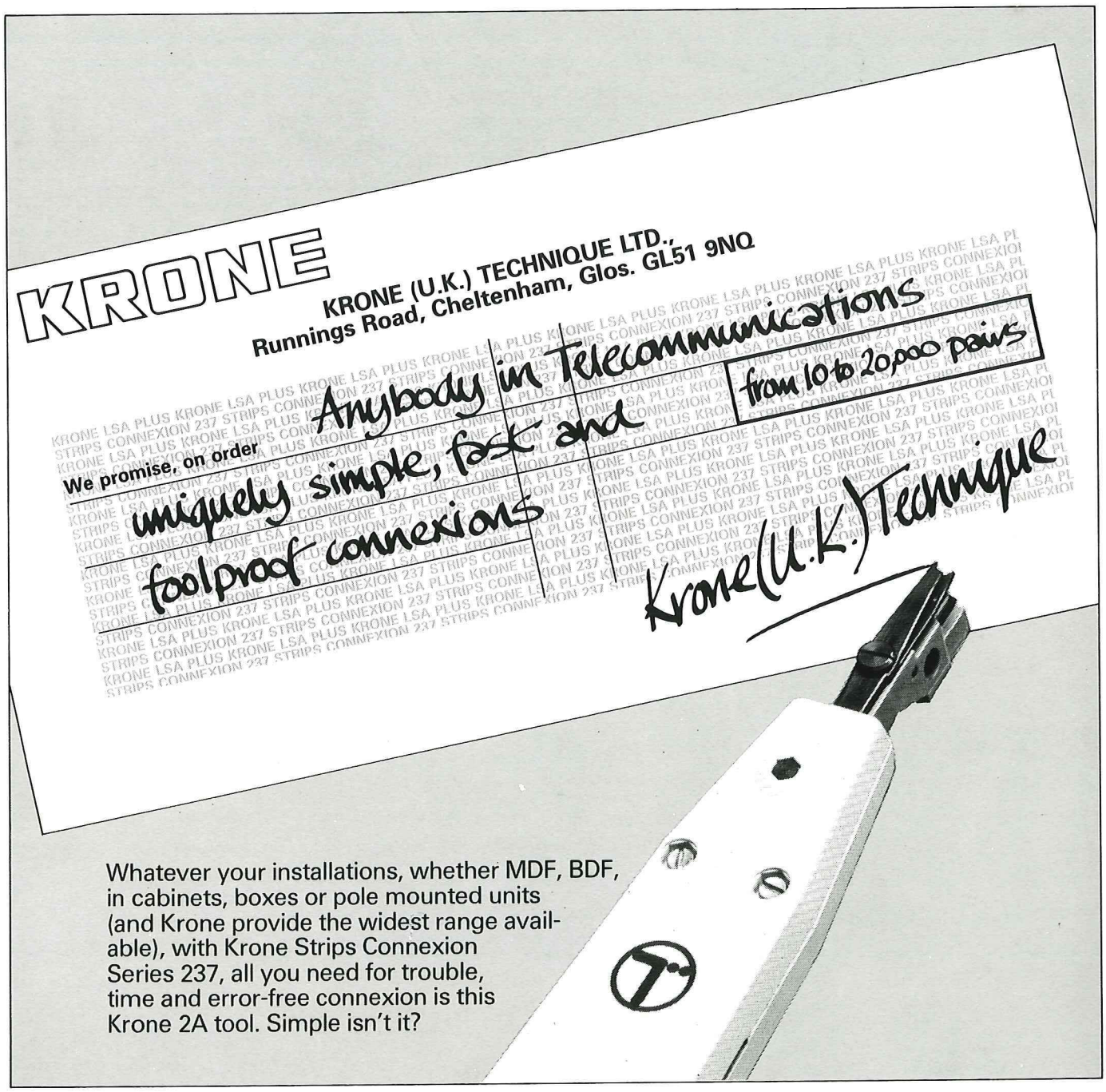

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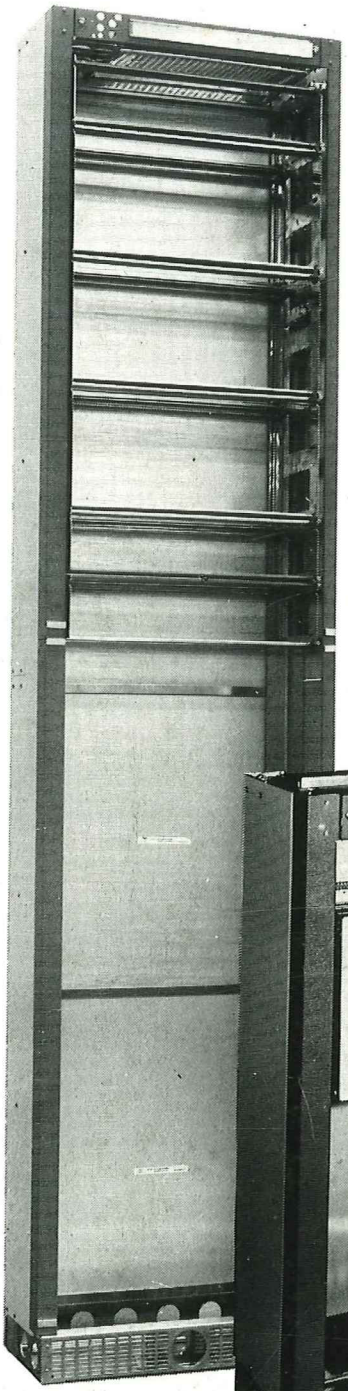

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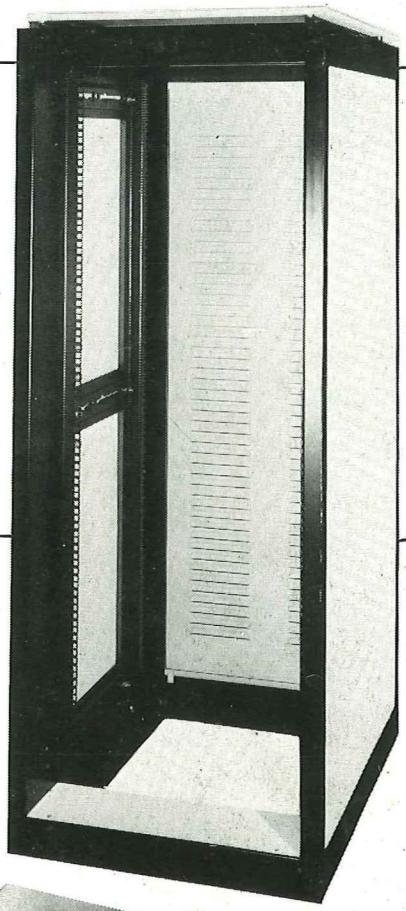

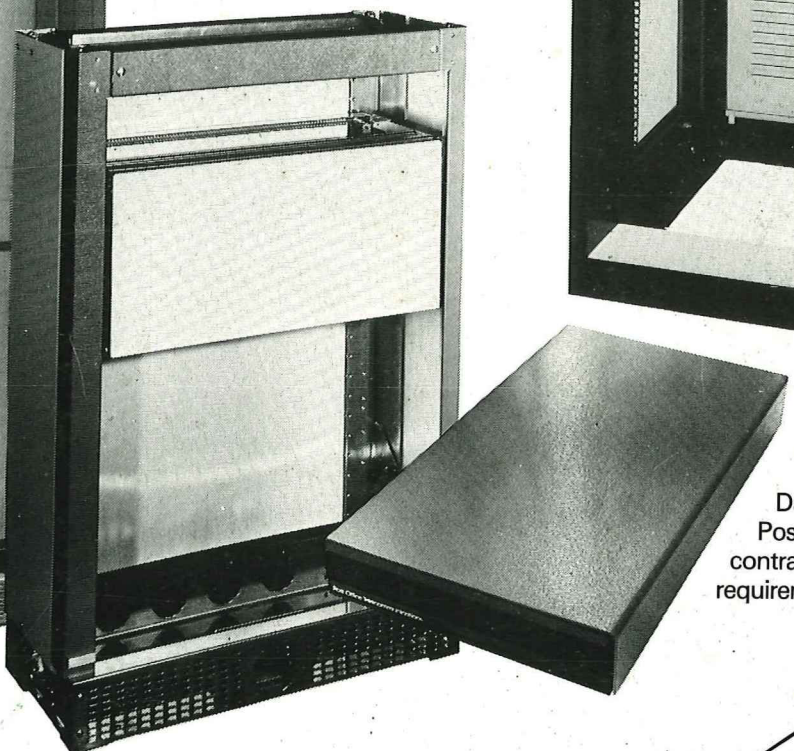

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